MANNED ORBITAL FACILITY: A USER'S GUIDE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PREFACE

The purpose of this document is to describe the features of a candidate Manned Orbital Facility concept and to solicit payload concepts, design suggestions, and innovations in approach from potential users of such a facility. As needs dictate, the free-flying Manned Orbital Facility could be made available in the mid-1980's to complement the Space Transportation System/Spacelab Program with a long-duration permanent orbital capability (with Space Shuttle logistic resupply) for a wide variety of earth-oriented applications and science missions. The reader/potential Manned Orbital Facility user of the future is encouraged to be as responsive as possible to the inputs solicited by NASA to support future Manned Orbital Facility planning activities (refer to Section 6).

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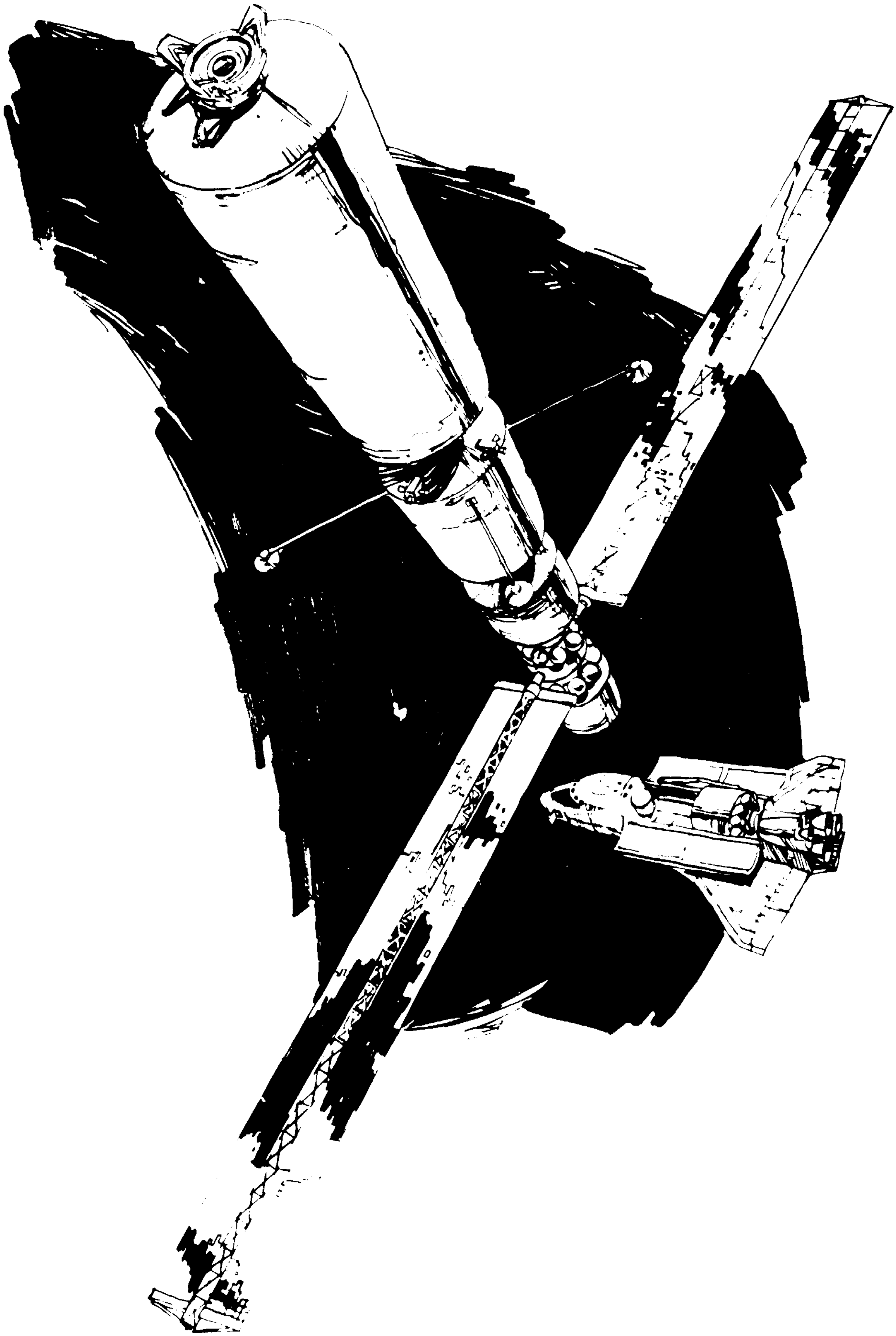


MANNED ORBITAL FACILITY OVERVIEW

FEATURES	CAPABILITIES
Manned onboard support to payloads	Initial facility in 1985 with four-man crew; potential growth to crew of 12 by 1990 if requirements dictate
Payload traffic to orbit	Nominal changeout and/or resupply at 90-day intervals; other payload service intervals available as required.
Onboard payload volume	Pressurized modules available to accommodate up to 5,800 cubic feet of payload equipment and supplies; payload capacity of Orbiter cargo bay for a single launch, about 10,000 cubic feet; multiple modules and/or launches available to handle very large payloads
Electrical power	8,000 watts continuously available for payloads; additional auxiliary power available as required
Environment	Pressurized sea-level shirtsleeve environment with full temperature and humidity control
Data management and communications	Continuous ground contact; real-time or delayed transmission; wideband (60 MHz)
Space-platform orientation	All-orientation vehicle stabilized to 0.1° with horizon and stellar attitude reference

CONTENTS

FIGURES

1 INTRODUCTION

With the advent of the Space Transportation System (Space Shuttle) in the 1980's, the cost and complexity of manned space operations will be substantially reduced, and new opportunities for space research, development, and applications programs will emerge. In preparation for these opportunities, NASA is examining the potential of a permanent, manned, earth-orbital facility designed to serve individuals and organizations whose research and applications goals can be furthered by use of the space environment.

This Manned Orbital Facility, or MOF, will initially provide living and working quarters for four persons. Later, should user needs so dictate, addition of more four-man units can modularly expand capabilities and enlarge operational capacity.

The purpose of this guide is to acquaint space payload planners and potential MOF users with the salient conceptual features and expected evolution of the facility. The baseline design is offered as a model against which the reader can compare his needs. The overall program is discussed, supporting services and resources are described, and examples of typical payload applications are given.

NASA hopes that this guide will stimulate payload planners and potential MOF users to participate in the program. The concept is completely flexible at this time, and suggestions for payloads, design requirements, and addition or alteration of features are invited. Submission of the questionnaire furnished at the back of this book will bring a prompt reply.

The general design features and configurations representing the baseline MOF have been developed and derived with due consideration given to applicable designs and subsystems such as those available in the Skylab, Orbiter, and Spacelab vehicles. In harmony with a cost-saving approach utilizing existing and proven designs to the maximum degree practicable, the MOF does not represent an advance in technology. Rather, it is appropriate to consider the MOF a complement to other elements of the Space Transportation System and Spacelab -- a complement that can provide, as economically as possible, an extended capability to satisfy the needs of users with expanding and evolving payload requirements.

2 PROGRAM OVERVIEW

MOF operations could begin by 1985 with the launch of the first four-man facility from the Eastern Test Range by the Space Transportation System (STS). The circular orbit will be nominally 200 nautical miles high and inclined at 28.5° Additional STS flights would be made at 90-day intervals to replenish supplies, deliver and retrieve payloads, and exchange personnel.

Approximately two years later, a second four-man facility could be launched into low polar orbit from the Western Test Range. Similarly scheduled logistic flights would be made to support the payloads and crew of this MOF.

A total of 19 representative payloads has been identified for the two facilities to date (see Section 5). The on-orbit activities required to support these payloads will occupy about 50% of the total manpower available in orbit during the first six to eight years of operation. The crew time remaining (about 68,000 man-hours) can be used to support the requirements of additional users and payloads.

The MOF will offer capabilities that are significantly more advanced than those of the space facilities and laboratories of the past or those planned for the near future. In particular, the time that a team of scientists and technicians can remain in space will be significantly extended. The longer-duration missions will allow time-dependent phenomena such as physiological adaptation and physical growth processes to be investigated, and advantage can be taken of the improved efficiency that will result from the crew becoming fully adjusted to the space environment and learning to work more effectively through repeated performance.

The longer missions will also offer potential cost savings. Timelines and work schedules can be less constrained than in the past, and therefore less subject to compromise if mission anomalies are encountered. Moreover, it will be possible to perform a given amount of work with fewer costly earth-to-orbit flights, and savings will also result in ground operations from the reduced number and complexity of turnarounds, refurbishment cycles, and checkout operations.

In addition, the longer-duration missions that the MOF will make possible will increase the breadth of research, development, and applications opportunities. For example, new instruments to survey, inventory, and monitor the distribution of the earth's natural resources will be used in MOF payloads to obtain extensive, detailed information over the full cycles of the seasons. Similarly, in the life sciences, the MOF laboratories can be used to study many problems requiring lengthy activity periods, complex manipulation, and control of multiple environmental factors.

These research areas and many similar ones that can be studied in the MOF have direct relationships to immediate needs on earth. For example, increased understanding of the growth phenomena of living organisms can assist directly in the establishment of more precise nutritional requirements; aberrations in cell division observed in space may be of direct importance in cancer research; the

manufacture in a weightless environment of extremely pure pharmaceuticals and materials with unique electrical or mechanical properties could yield new products with new capabilities; and learning more about the sun may help in meeting our growing energy needs and improving our communications.

Potential paths for evolutionary growth of the MOF are illustrated in Figure 2-1. It is expected that as the payloads are operated in orbit, their products -- whether scientific data or materials fashioned in space -- will lead to requirements for further missions and flights. Because of the modular nature of the MOF concept, eight- to twelve-man facilities could follow earlier four-man missions as 1990 is approached. As an example, it could be speculated that after an initial five years of prototype and pilot-plant operation, a space-manufacturing activity on a commercial scale would be warranted. These industrial-class operations would, in turn, call for much larger work forces and more MOF units.

Additional MOF facilities could be established in high-altitude subsynchronous and geostationary orbits for such missions as satellite servicing and synchronous observatory operations.

The MOF can service payloads for many different missions in a variety of orbits, as shown in Figure 2-2. The STS is capable of delivering the MOF and its payloads directly to low earth orbits (altitudes less than 300 nautical miles) in either 28.5° or polar inclinations. These two classes of low earth orbits, which are achievable from the Eastern and the Western Test Ranges, offer a wide spectrum of mission opportunities in fields such as earth observations, stellar and solar astronomy, and space physics. In addition, these orbits provide the microgravity environment useful to life-science and material-research programs.

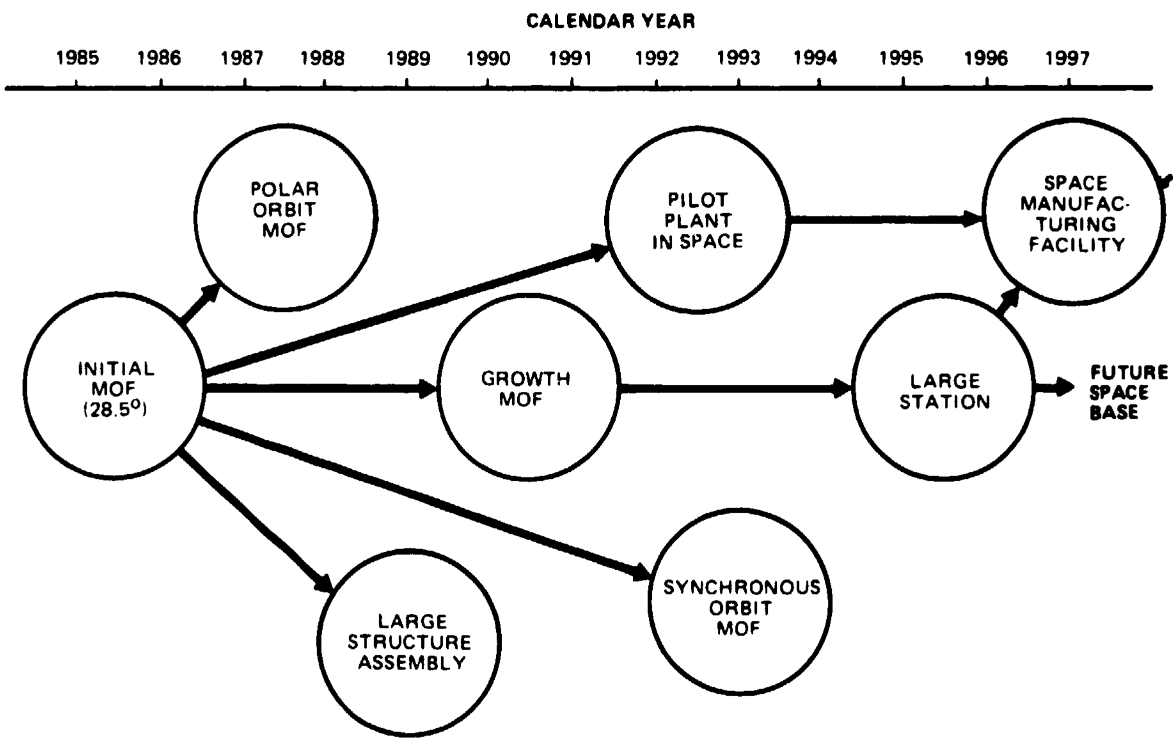


Figure 2-1. MOF Evolutionary Paths

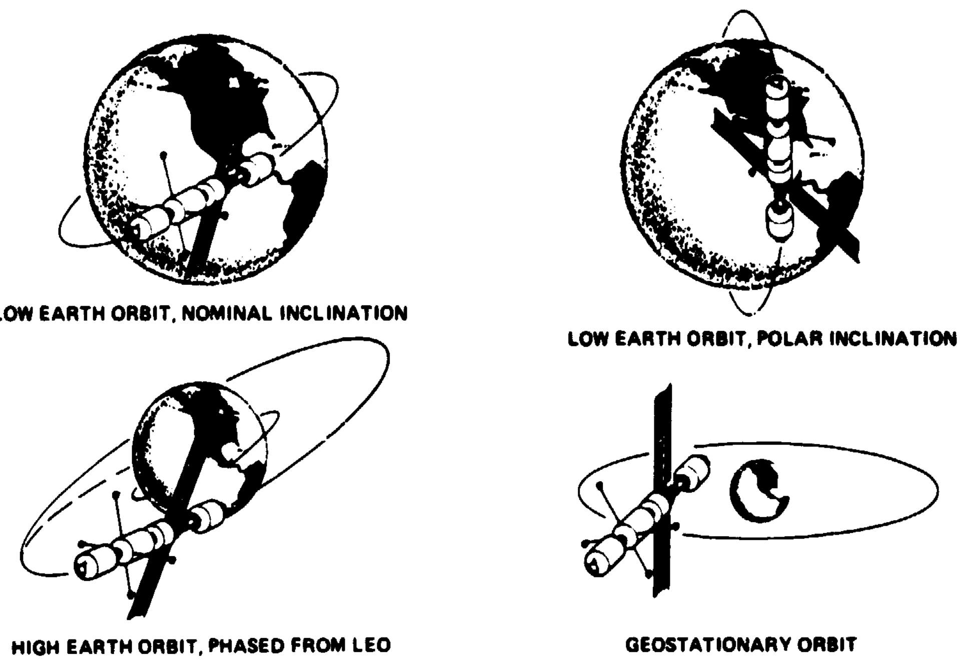


Figure 2-2. MOF Mission Profiles

The MOF could also support payloads that require stations in high-altitude earth orbits (perhaps 4,000 nautical miles). For example, the facility could be used to assemble a large-aperture (200-meter) radio telescope in low orbit. After final checkout, the telescope could be transported to the higher orbit to begin its program of unattended operation.

As further discussed in Section 4, perhaps the most important attribute offered by MOF is the presence of man to conduct and support onboard payload operations. By relying on manual functions rather than automation, many elements of the MOF and the payloads can be made simpler, less costly, and more reliable. Add further the inherent intellectual capacity of man, which will permit on-the-spot objective judgments to be made and innovative or remedial action to be taken to compensate for the unforeseen, and the MOF offers significant advantages to potential users.

3 BASELINE DESIGN DESCRIPTION

The modular MOF configuration is made up of four basic elements (Figure 3-1):

Subsystem Module (SM)	Provides electrical power, environmental control, centralized communications, stabilization and control, maneuvering capability, and hygiene facilities.
Habitability Module (HM)	Provides for basic crew needs such as eating, sleeping, and recreation; also serves as the central focus and control point for payload operations.
Logistics Module (LM)	Provides for resupply of consumables and changes of equipment; also serves as additional habitable volume and storage space in orbit.
Payload Module (PM)	Houses scientific apparatus, applications equipment, and service-oriented functions.

The cylindrical modules are fitted at each end with an International Docking Assembly to permit their attachment and clustering in space. The International Docking Assembly also furnishes a standardized means of access for rescue operations.

The HM and SM are mated on the ground and launched together as a single unit. The HM, SM, and LM are "core" modules that provide support resources for a variety of interchangeable PM's.

The first STS launch inserts the HM and SM into orbit. The second launch delivers the LM and the first PM. Resupply flights follow at nominal 90-day intervals. On these flights, the LM is interchanged to replenish the MOF with 90-day stores of food, propellants, and other expendables. The PM's may be launched with the LM or launched individually, depending upon available and needed weight, volume, and schedule. Supplies and equipment for payloads already onboard also may be carried as required on logistic flights.

Payloads are retrieved when the STS Orbiter is on station and are returned to earth or retained for reactivation at a later time in the Orbiter payload bay. If traffic conditions warrant, payloads and PM's can be left attached to the MOF in a deactivated condition for return to earth at a later time.

For some payloads or missions utilizing the MOF resources, a geostationary orbit may be required or attractive. Such higher-energy orbits can be achieved by using the Space Tug (which is also launched by the STS) for a series of staged boosts.

The HM (Figure 3-2) is the focus of onboard activities. The payloads are monitored and controlled from this module, which also contains the galley and crew quarters. In addition, the HM houses the master communication console, where both voice and electronic data links can be established with the ground.

The SM (Figure 3-3) contains the basic resources for the MOF. The vehicle-stabilization gyroscopes, the horizon sensors, the stellar-reference sensors, and the other elements of the control system are located here. The solar arrays are deployed from this module, which also contains the electrical power conditioning equipment and the distribution circuits. All equipment is designed to be fully serviceable and repairable in orbit.

The LM, shown in Figure 3-4, may be interchanged during each visit by the Orbiter. The LM contains storage for fresh supplies and space for returning experiment samples, equipment, and waste to earth. The module also contains tankage for the reactants and reserves needed to sustain the MOF during the 90-day interval between logistic missions.

The orbital configuration of the three core modules is shown in Figure 3-5.

The nominal crew complement is four. Since there is no requirement for the MOF crewmen to pilot the Orbiter (that need is met by its commander and crew) and housekeeping is minimal, all MOF crew members can be highly trained payload specialists. A crew of four provides a sufficiently broad skill base to support any payload or reasonable combination of payloads that would be operational during a typical 90-day period.

The pressurized compartments of the MOF are conditioned to furnish a comfortable shirtsleeve environment for the payloads and crew. The core modules as well as the payload modules contain adequate working volume to permit onboard activities to be performed efficiently.

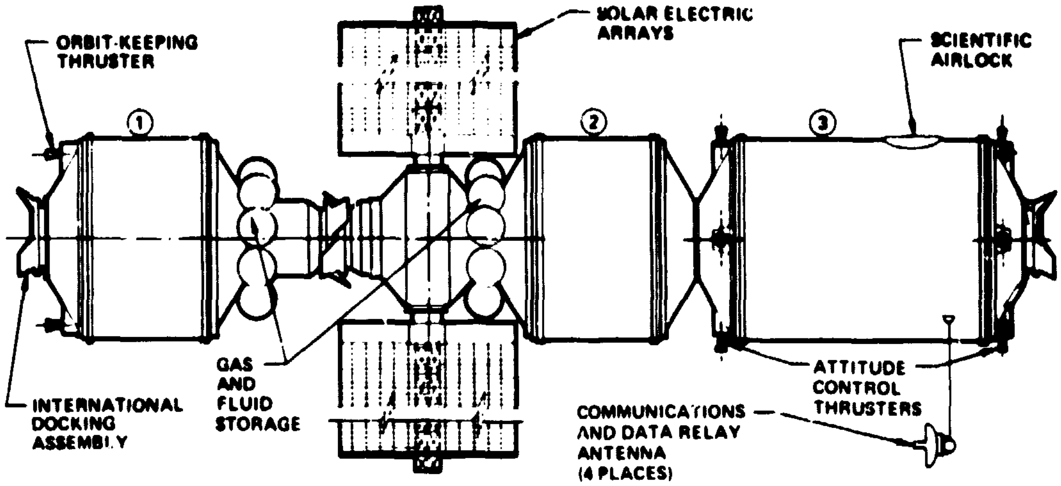
Provisions are included for extravehicular activity (EVA) to be performed as a routine operation for servicing of certain types of payloads and the MOF itself. The crew passes outside through an airlock. In their space suits, they can remain out for as long as six hours per day for tasks such as film canister replacement, adjustments, malfunction correction, structure assembly, repair and servicing of satellites, and deployment of large instruments and structures.

During the "normal" workday inside the MOF, each of the four crewmen is available for eight hours of work on payload activities. The normal work week allows each crewman one day in seven when he is not assigned specific payload duties.

When extended work periods are necessary, shifts up to 12 hours in length are feasible. This accelerated work pace can be maintained about 15% of the time, if required.

In general, the schedule of onboard activities calls for all crew members to eat and sleep at the same time. However, two-shift or continuous operations can be scheduled if required for special payload activities.

The MOF is completely dedicated to the support of user payloads. The resources of the facility that are available to the users, in addition to the resources represented by the crew, include the basic structure; the electrical power and distribution system; the stabilization and control system; the communications and data-management system; the environmental control and life support system; and the crew support system.



ELEMENT	(1) LOGISTICS MODULE (LM)	(2) SUBSYSTEM MODULE (SM)	(3) HABITATION MODULE (HM)
FUNCTION	FLUID SUPPLY, BULK CARGO, WASTE STORAGE	ELECTRICAL POWER, STABILIZATION, COMMUNICATIONS, HYGIENE	LIVING QUARTERS, PAYLOAD MONITORING, STOWAGE, GALLEY
LENGTH (m)	6.9	7.9	7.5
WORKING VOLUME (m^3)	37	37	68

Figure 3-1. Outboard Profile, MOF Core Modules

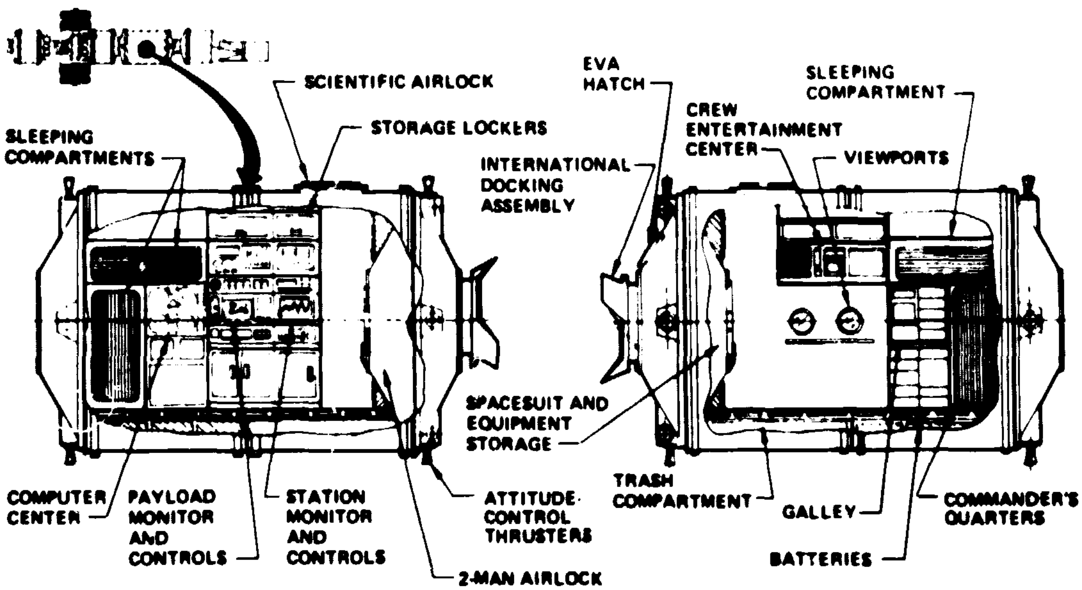


Figure 3-2. Inboard Profile, Habitability Module

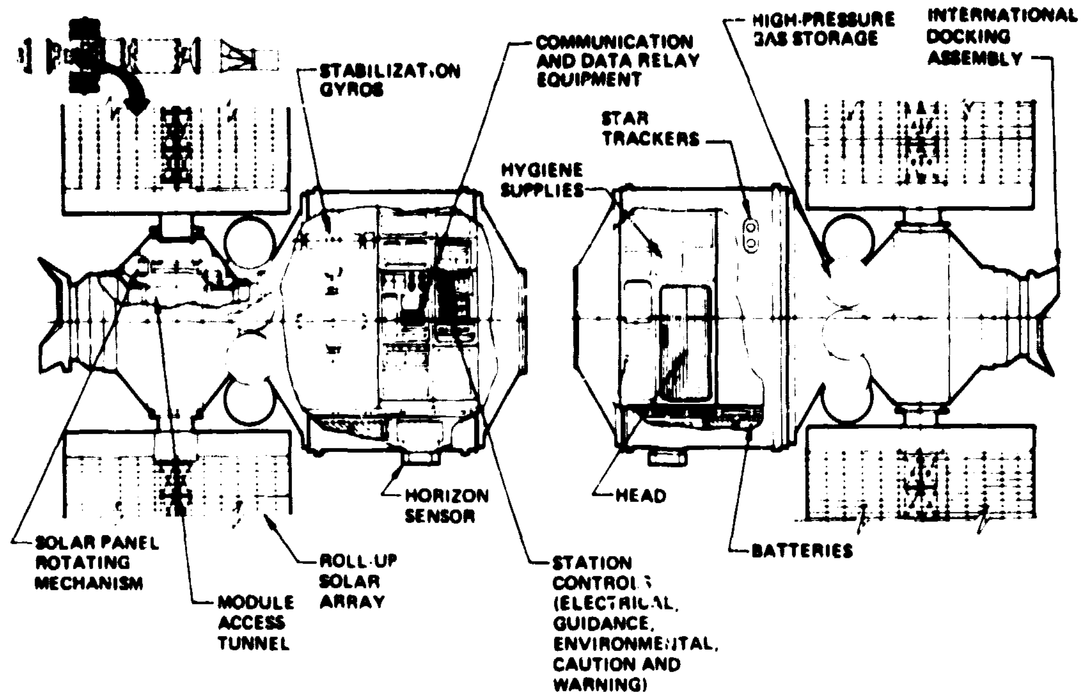


Figure 3-3. Inboard Profile, Subsystem Module

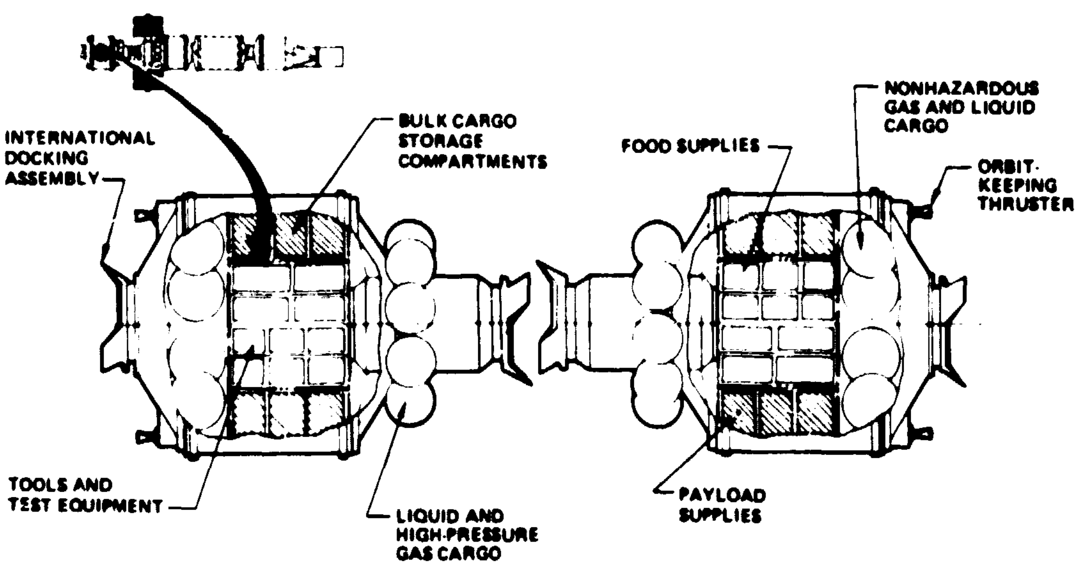


Figure 3-4. Inboard Profile, Logistics Module

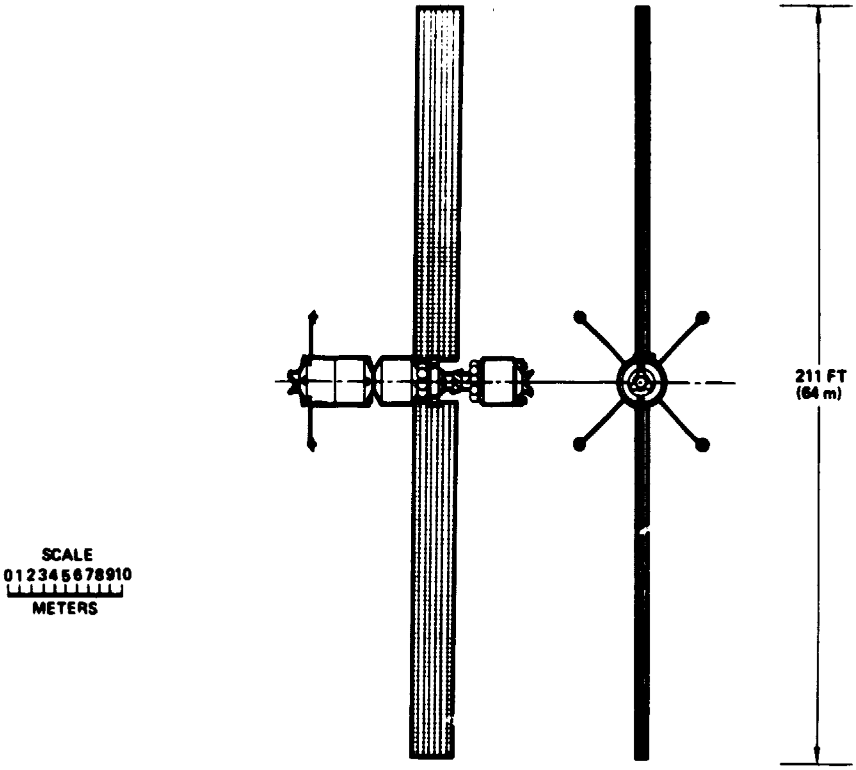


Figure 3-5. MOF Flight Configuration

STRUCTURE

The basic module pressure shells consist of 13-foot nominal-diameter cylindrical sections about 9 feet long. The sections are constructed of machined aluminum-alloy plate and are joined at bolted, gasketed flanges, which also mate with the conic end-dome sections and the International Docking Assemblies at the ends of the modules. The interiors of the pressure shells are outfitted with standardized floors and equipment or storage racks. Outside the pressure shells are shrouds that provide thermal insulation, meteoroid protection, and support for the fluid circuits of the thermal control system radiators.

The HM, SM, and LM provide approximately 5,700 cubic feet of working volume. Additional space is available in the payload modules. Storage space, in addition to that required for the provisions and supplies needed to sustain 90 days of operation, is included to accommodate payload equipment and payload-related supplies. About 100 cubic feet are enclosed in standardized lockers and cabinets, and about 500 cubic feet of free space are available in which items can be secured to the floor or the bulkheads.

The HM is equipped with two airlocks, one for EVA and another for the deployment of payloads outside the MOF. Conveniently located viewports have optical-quality windows suitable for precision photography. The installation and design of the equipment racks permits access to all items that require periodic maintenance or may need to be repaired.

ELECTRICAL POWER AND DISTRIBUTION SYSTEM

The electrical power and distribution system provides continuous power of 12,000 watts. Nominally, 8,000 watts are available for the payloads, but peaks of 10,000 watts can be drawn by the payloads for short periods of time. The primary bus voltage is 28 VDC; inverters can provide AC as required.

Utility outlets are provided at convenient points in each module. Circuit breakers protect both the payloads and the power distribution system from overloads and line faults. Circuit-branching features prevent an interruption in one circuit from affecting other circuits.

STABILIZATION AND CONTROL SYSTEM

The MOF is equipped with an all-attitude orientation capability. Attitude is controlled through stabilization gyroscopes, which act to fix the axes of the MOF inertially at the desired attitude. Horizon sensors and star trackers provide earth-oriented and stellar-referenced pointing capabilities.

The axes of the MOF are positioned to within ±0.1° of the desired attitude with a residual rate of less than 0.01°/sec. Reaction-control thrusters are employed for gyro desaturation as well as for orbit-keeping velocity makeup. The thrusters use nitrogen gas as propellant. This system has the advantage of issuing effluents that are not possible sources of contamination.

Onboard computational capbilities permit instruments and sensor packages to be referenced to both time and space standards. Ground-tracking data are also available onboard to define with high precision the facility's orbital parameters, including orbital position and velocity, as required by user payloads.

COMMUNICATIONS AND DATA-MANAGEMENT SYSTEM

MOF communications use the Tracking and Data Relay Satellite as the primary link with the ground. Two video (4.6 MHz) channels, one wideband (60 MHz) telemetry channel, one 128-kbps telemetry channel, and two voice circuits furnish the primary downlink data-return capabilities. Two 32-kbps voice circuits and one 2-kbps digital data command link constitute the uplink capability. Similar voice circuits and command channels are available for MOF-to-Orbiter communications, links to other spacecraft, and EVA.

Access to the data-management capability and the centralized data processor is provided by terminals located in each module of the MOF. Each terminal includes a cathode ray tube display that is computer-generated and is capable of both alphanumeric and graphic presentations. Operators gain access to the system through keyboards and/or the teleprinter.

A wide variety of software is available to adapt the data-management capability to the needs of the payloads. Actual payload monitoring and control, as well as data-acquisition recording and down-linking, can be performed in real time under the direction of the processor.

Portable closed-circuit television (CCTV) is available. Lights, recorders, and monitors can be set up anywhere inside the MOF. Provisions are also made for using exterior CCTV to monitor EVA and payload operations. The video from the CCTV can be patched to downlinks for real-time broad-casting to the ground, a feature that is especially desirable for educational activities.

ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEM

The atmosphere conditioning, purification, and distribution functions are performed by the environmental control and life support system. The system not only maintains the cabin atmosphere at the comfort-zone level of 72 ± 2°F and 40% relative humidity, but also removes metabolic carbon dioxide and other trace contaminants. Thermal loads up to the equivalent of 12 kilowatts (8 kilowatts from the payloads) are also rejected by this system. The onboard supply of water for crew use is maintained by a closed-loop recovery subsystem, which eliminates the need to resupply large quantities of water on each logistic flight.

The atmosphere consists of a standard sea-level nitrogen-oxygen mixture controlled to a nominal 15-psia pressure. The system is open-loop with oxygen uptake, leakage, and loss due to airlock operations made up from storage tanks. The atmosphere supply is replenished by logistic flights.

CREW SUPPORT SYSTEM

Equipment and facilities for crew hygiene and for food storage and preparation, as well as furnishings, wearing apparel, and equipment for exercise and recreation, are provided by the crew support system. Also included are general-purpose aids such as mobility devices, restraints, cargo-handling fixtures, tools, test equipment, portable lights, cameras, and radiation-monitoring devices. Emergency supplies of oxygen and food maintained in each module are also part of this system.

4 PAYLOAD SUPPORT SERVICES

OVERALL SUPPORT CHARACTERISTICS

The most important payload-support characteristic of the Manned Orbital Facility is the availability of man as an observer, decision-maker, and operator. Experience on Skylab offers substantial evidence that the presence of astronauts can add significantly to mission success and enhance the productivity of spaceflight activities.

Human presence in orbit offers particular advantages with respect to improvisation and modification. The resetting of circuit breakers and the relocation of power cables to service different apparatus are two examples of how crewmen have played contributory roles.

The presence of crewmen may also allow the heat-rejection system to be simpler and lighter because temporary measures can be installed to accommodate periodic or transient above-normal loads. This was illustrated on Skylab when the crewmen corrected the heat balance of the workshop by erection of makeshift thermal shields. (Later in the mission, the crew also prevented serious difficulties by restoring the malfunctioning coolant loop to service.)

In data management and communications, the crewman will play a role of prime importance. His presence will allow the system to be simpler and less expensive, with plug-in panels instead automatic switching, and he will be able to make discretionary judgments with respect to what data are to be handled, how they are to be channeled and processed, and where they are to be routed. A crewman can also initiate or suspend communications or data-management functions as required to better use the capacity of the system.

To make maximum use of man's visual perception, viewports and other optical devices will be provided for functions such as overall control of vehicle orientation and maneuvering. In this case, the operator will be positioned so that he can see directly through viewports, particularly during close-in maneuvers (for example, during docking). Remote sensors will also be used to present information on visual displays.

Also of great importance is the continuous microgravity environment offered by the MOF. This environment cannot be duplicated on earth except for short periods of time, during which gravity-induced convection and seismic vibrations can disturb many measurements. In space, such disturbances are avoided or minimized. The role of gravity in life processes can be studied systematically, and the long-duration life-science investigations that are essential to planning and design of very-long-term manned-space missions can be conducted.

Also of significance from a payload-support standpoint are access to an unlimited vacuum; availability of a vantage point from which the earth, the sun, and stellar objects can be viewed without the disturbances encountered on earth; access to solar energy as a source of contamination-free thermal power; and the availability of deep space at 4° K as a radiation sink.

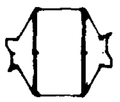
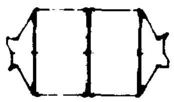
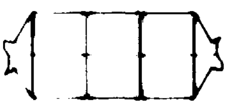
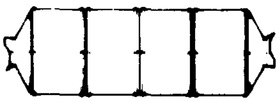
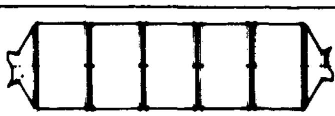
PHYSICAL SUPPORT CHARACTERISTICS

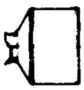
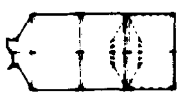
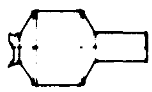
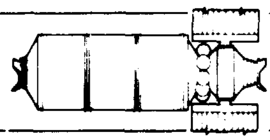
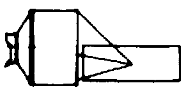
The payload module is the primary means for support of payloads. While it is possible to deliver payloads that are not integrated into a module, the PM offers a number of important features. Among these are the standardized on-orbit interface made possible by the International Docking Assembly and the electrical-power, data-bus, fluid-transfer, and control interfaces that are common to all modules.

PM's vary widely to meet the needs of different users (Figures 4-1 and 4-2). The modules are constructed from a few standardized components, as shown in Figure 4-3, which allows a particular configuration to be tailored to the requirements of the individual user without special development. Both pressurized and unpressurized volume are available in the modules for payloads and general-purpose equipment. The modules are outfitted with standardized supporting structure and equipment, including floors, overheads, equipment-mounting racks, utility outlets, lighting fixtures, storage cabinets, and atmosphere-supply tanks.

For payloads installed in or serviced from a PM, the following resources are available:

Electrical power	8,000 watts at utility outlets, auxiliary power available as required.
Communications and data management	Real-time up- and downlinks, onboard recording, CCTV, computer-serviced situation displays, wideband (60 MHz) two-way circuits to ground.

	PAYLOAD MODULES	MODULE WEIGHT, LB*	PAYLOAD AND SUPPORT EQUIPMENT, LB*	WORKING PRESSURIZED VOLUME, FT³ (TOTAL VOLUME, FT³)**
A		6,875	25,125	420 (1,160)
B		8,100	23,900	840 (2,320)
C		9,250	22,750	1,680 (3,400)
D		10,500	21,500	2,100 (4,640)
E		11,000	20,[illegible]00	2,520 (5,000)

	PAYLOAD MODULES	MODULE WEIGHT, LB*	PAYLOAD AND SUPPORT EQUIPMENT, LB*	WORKING PRESSURIZED VOLUME, FT³ (TOTAL VOLUME, FT³)
F		4,250	27,750	NONE (1,100)
G		9,050	22,950	800 (3,400)
H		6,100	25,900	500 (1,300)
I		10,000**	13,000	1,300 (3,400)
J		6,425	25,575	NONE (1,100) PLUS SPACELAB PALLETS

*ACCOMMODATION WEIGHTS BASED UPON PLANNED ORBIT PAYLOAD LANDING WEIGHT OF 32,000 LB. AN ADDITIONAL 33,000 LB IS AVAILABLE IF ORBITER RETURN INTACT IS NOT PLANNED.

Figure 4-1. Payload Modules A Through E

Figure 4-2. Payload Modules F Through J

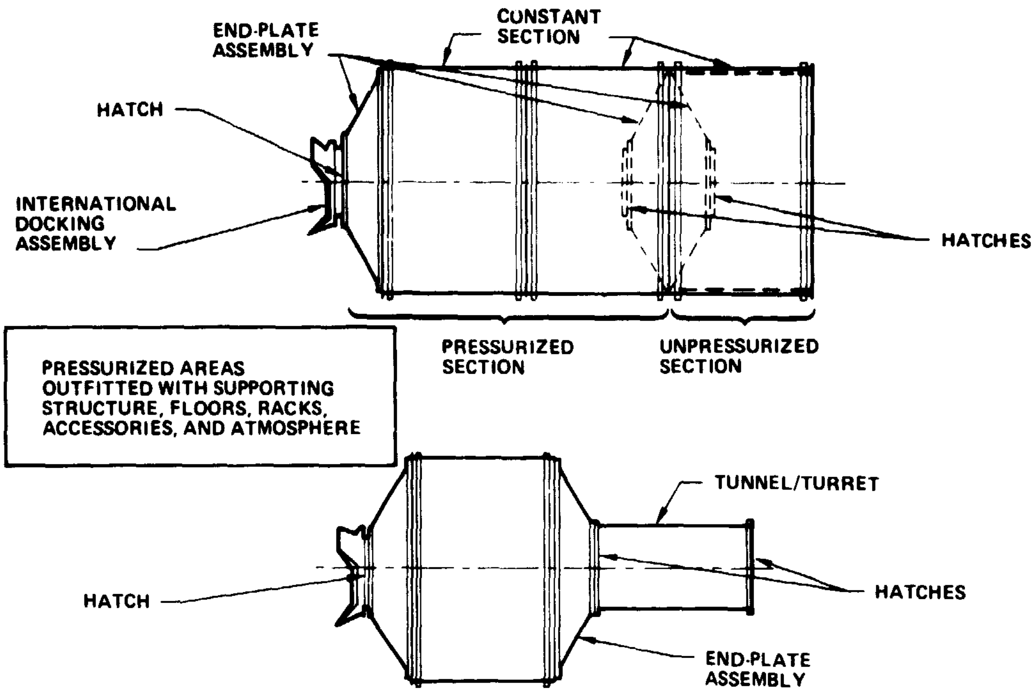


Figure 4-3. Examples of Payload Modules That Use Standardized Components

Stabilization and control	Stellar-inertial, solar-inertial, and local-vertical orientations; horizon and stellar references.
Atmosphere	Standard 15-psi atmosphere; temperature and humidity controlled; cooling air for equipment.
Orbits	Nominal- and polar-inclination low orbits (200 nautical miles) for early operations; high-altitude earth orbits (4,000 nautical miles) and geostationary orbits.
Microgravity	Onboard null-gravity levels to 10^{-5} g for extended periods for payloads attached to the MOF; lower levels (10^{-6} to 10^{-7} g) available for free-flying modules and subsatellites.
Pointing	Stabilized platforms for sensor pointing and unrestricted viewing from orbit.
Access to space environment	Space environment's vacuum, solar input, and freedom from contamination continuously available.

Crew support	Average of 32 man-hours per day available to payloads; EVA activities can be planned for 6 hours for two crewmen on 4 days out of each 5-day period; special skills and payload-oriented expertise available.

STS PAYLOAD-SUPPORT CHARACTERISTICS

All transportation to and from orbit is provided by the Space Transportation System. The flight portion of this system consists of the Orbiter, the External Tank, and two Solid Rocket Boosters (Figure 4-4). The Orbiter is the element that delivers and retrieves cargo and payloads in space.

The Orbiter bay can accommodate a maximum payload length of 60 feet and a maximum diameter of 15 feet. A total payload weight of 65,000 pounds can be launched. Planned cargo weight at landing (when payloads or other MOF system elements are returned to earth) is limited to 32,000 pounds.

Figure 4-5 shows the Orbiter in its flight configuration with the payload bay open. During the powered portions of flight, payloads will be subjected to the vibration, acoustic, and pressure environments shown on the figure.

Two typical mission years for the MOF – one for an orbit inclined at 28.5° and the other for a polar orbit – are charted in Figures 4-6 and 4-7.

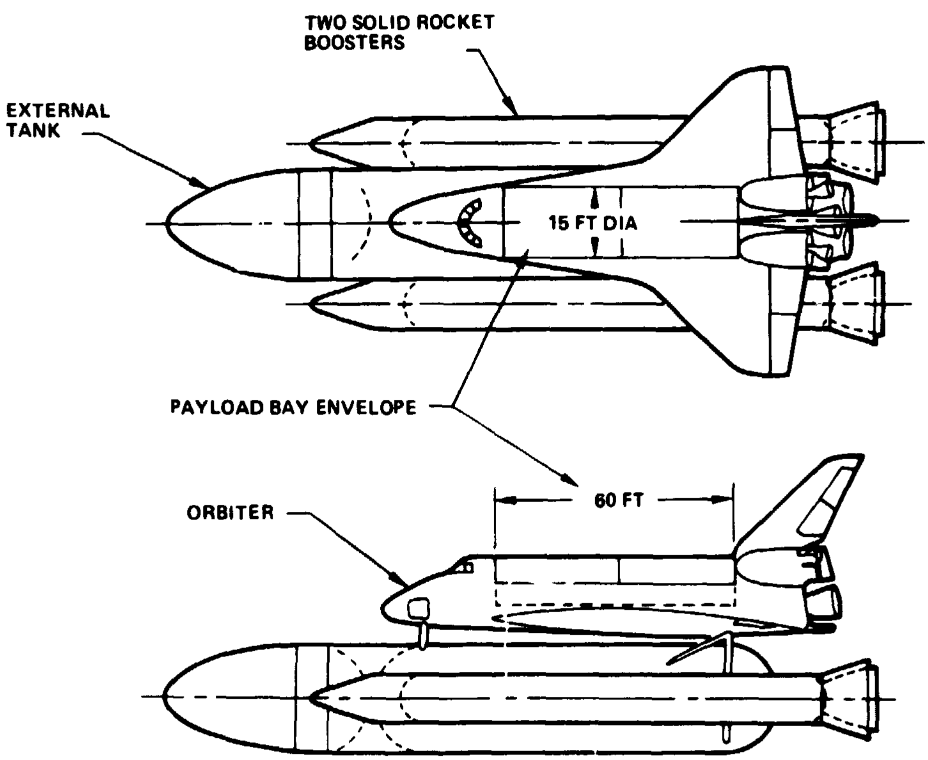


Figure 4-4. Space Transportation System Launch Configuration

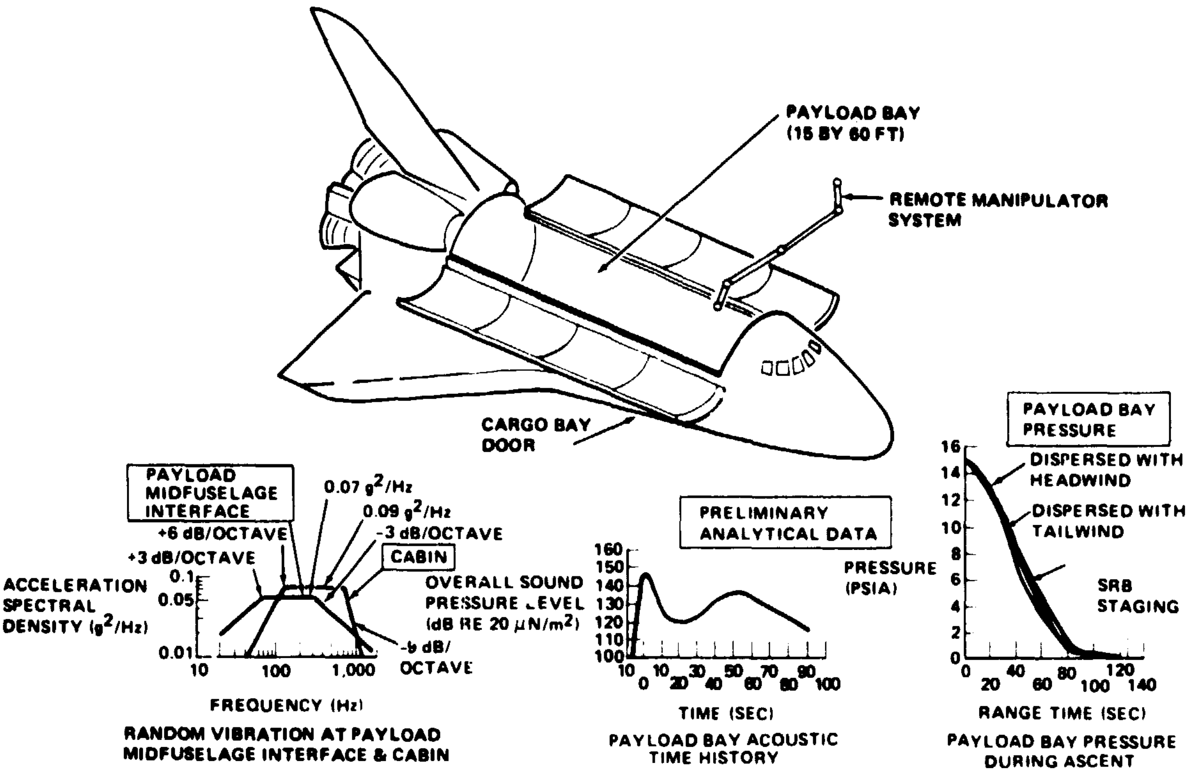
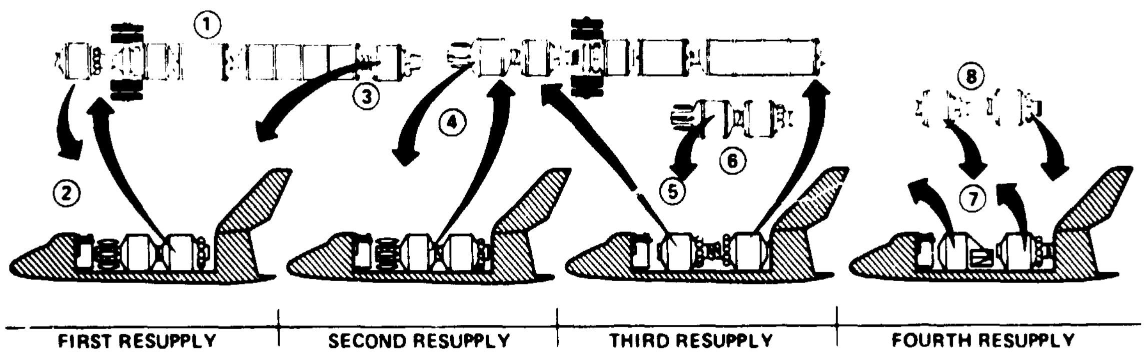
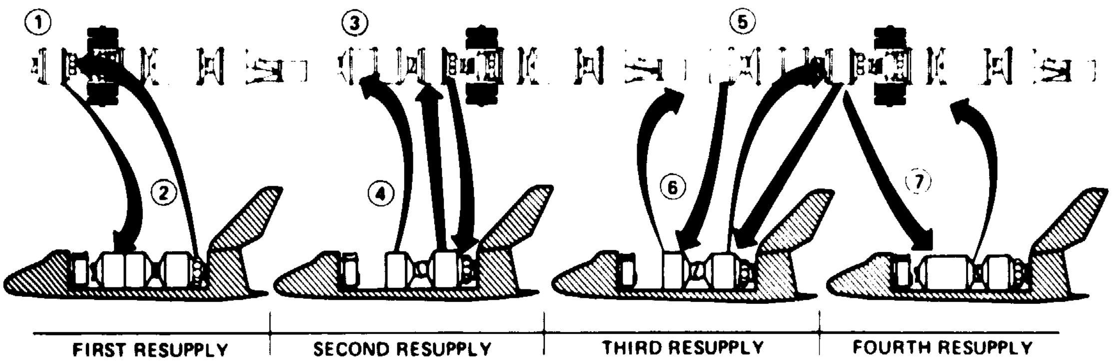


Figure 4-5. Orbiter Payload-Bay Environment



THE MOF IS LOCATED AT 250 NMI ALTITUDE AND 28.5° INCLINATION. DURING THE YEAR OF OPERATIONS SHOWN, TWO MOF PAYLOAD COMBINATIONS ARE SCHEDULED TO OPERATE OUT OF THE FACILITY: C-12, LIFE SCIENCES/ TECHNOLOGY NO. 1, AND C-11, HE ASTROPHYSICS/TECHNOLOGY, WHICH WILL FLY TWICE DURING THE YEAR. AT THE END OF THE PRIOR YEAR, THE MOF WAS CONFIGURED AS SHOWN AT (1) TO ACCOMMODATE PAYLOAD C-12. DURING THE FIRST RESUPPLY, AS SHOWN AT (2), THE ORBITER DELIVERS A LOGISTIC MODULE AND THE PAYLOAD MODULE CONTAINING C-11. THE ORBITER RETURNS THE TWO SPENT LOGISTIC MODULES, ONE OF THESE HAVING BEEN USED TO SUPPORT THE LIFE SCIENCES/TECHNOLOGY LABORATORY PAYLOAD MODULE AS SHOWN AT (3). THE LABORATORY PAYLOAD MODULE IS DEACTIVATED AND REMAINS ATTACHED TO THE MOF. DURING THE NEXT RESUPPLY, THE LOGISTIC MODULE AND C-11 PAYLOAD MODULE ARE EXCHANGED AS SHOWN AT (4). DURING THE THIRD RESUPPLY, THE ORBITER DELIVERS TWO LOGISTIC MODULES, AS SHOWN AT (5), AND THE MOF REINSTATES THE C-12 PAYLOAD CONFIGURATION. THE C-11 PAYLOAD MODULE AND LOGISTICS MODULE ARE RETURNED AS SHOWN AT (6). THE FOURTH RESUPPLY IS AVAILABLE, AS SHOWN AT (7), TO DELIVER THE NEW PAYLOAD MODULE FOR C-3, SOLAR OBSERVATIONS, WHICH IS THE NEXT PAYLOAD FLIGHT SCHEDULED, ALONG WITH A FRESH LOGISTIC MODULE. THE LABORATORY MODULE IS DEACTIVATED PENDING ITS NEXT SCHEDULED USAGE AT A LATER DATE. THE TWO SPENT LOGISTICS MODULES ARE RETURNED, AS SHOWN AT (8), TO COMPLETE A YEAR'S FLIGHTS.

Figure 4-6. Typical Mission Scenario for 28.5° Orbit



THE MOF IS LOCATED AT 370 TO 400 NMI ALTITUDE AND 90° INCLINATION. DURING THE YEAR SHOWN THREE MOF PAYLOAD COMBINATIONS ARE SCHEDULED TO OPERATE OUT OF THE FACILITY: C-4, SPACE SCIENCES NO. 1; C-9, EARTH SCIENCES NO. 1; AND C-10, EARTH SCIENCES NO. 2. C-9 AND C-10 FLY TWICE DURING THE YEAR. AT THE END OF THE PRIOR YEAR OF OPERATION, THE MOF IS CONFIGURED AS SHOWN AT ① TO ACCOMMODATE PAYLOAD C-4. DURING THE FIRST RESUPPLY, THE EARTH SCIENCES LABORATORY PAYLOAD MODULE AND THE LOGISTICS MODULE ARE DELIVERED TO THE MOF. THE FIRST MISSION SEGMENT CONTINUES WITH C-4 ACTIVITIES, HAVING BEEN RESUPPLIED WHILE THE LABORATORY MODULE WAS BEING ACTIVATED, AS SHOWN AT ③ . THE SECOND RESUPPLY DELIVERS THE C-9 SENSORS FOR DOCKING TO THE LABORATORY PAYLOAD MODULE. SOME OF THE C-9 SENSORS ARE ALSO USED WITH C-10, WHILE MUCH OF THE LABORATORY SUPPORT FACILITIES ARE ALSO COMMON TO THE TWO PAYLOADS. THE MOF CONFIGURATION FOR C-9 AND C-10 IS SHOWN AT ⑤ . THE THIRD RESUPPLY EXCHANGES THE SENSOR PAYLOAD MODULE AND THE LOGISTICS MODULE AS SHOWN AT ⑥ , WHILE THE C-9 AND C-10 PORTIONS OF THE MISSION CONTINUE. WITH THE FOURTH RESUPPLY, THE LABORATORY PAYLOAD MODULE IS INTERCHANGED WITH THE LABORATORY PAYLOAD MODULE CONTAINING THE EQUIPMENT REQUIRED FOR C-5, SPACE SCIENCES NO. 2, WHICH IS SCHEDULED TO BE ACTIVATED DURING THE NEXT MISSION PERIOD, AS SHOWN AT ⑦ THE C-9/C-10 LABORATORY PAYLOAD MODULE IS RETURNED.

Figure 4-7. Typical Polar-Orbit Mission Scenario

5 PAYLOAD ACCOMMODATION

In general, the MOF is intended to support the following classes of space activity:

- Scientifically oriented investigations in the fields of astronomy, astrophysics, solar physics, physics and chemistry in microgravity, life sciences, and earth sciences.
- Technologically oriented applications in the fields of meteorology, earth observations, communications, navigation, material processing, and manufacturing in space.
- Space-basing operations, including assembly of large structures, station buildup, construction of permanent manned facilities, and (eventually) building of space colonies.
- Support of space operations through in-orbit spacecraft servicing, vehicle refueling, and maintenance and repair of space-system elements.
- Monitoring and control operations, including staffing of permanent, manned, air- and space-traffic control facilities, communication stations, and observatories.
- Military applications and defense measures.

Heretofore only the first two classes have been studied in some detail. The MOF baseline design has been configured to accommodate 19 payloads that are related to these classes. The payloads were derived from the Space Shuttle Payload Description Activity (SSPDA), a NASA planning effort that has defined more than 200 individual manned and automated payloads for the first 12 years of STS operation. The 19 payloads chosen for use in establishing the MOF baseline are representative combinations of SSPDA payloads and the classes of activities that could be served by the MOF in the initial six- to eight-year time period (Table 5-1).

A hypothetical MOF flight schedule for the 19 payloads is shown in Figure 5-1. Two facilities are needed to support the payload activities. An MOF in a 28.5° orbit would serve 10 payloads, and the first flight of Payload C1 would be in 1985. The MOF in polar orbit would begin to support Payloads C4, C5, and C6 about two years later and would serve and support nine payloads over the seven-year period indicated.

In addition to the MOF-SSPDA payload traffic, Figure 5-2 shows periods when other orbital activities could be scheduled. For example, a growth version of the MOF that would support additional crewmen could become available in 1989 to support such activities as assembly of large structures and space manufacturing. In the 1990-1991 time frame, an MOF could be established in synchronous orbit for satellite servicing and other classes of missions at geostationary altitude.

Table 5-1

MOF-SSPDA PAYLOAD COMBINATIONS

Payload	Name	Description
C1	IR Astronomy	1.5-m cryogenic-cooled and 3-m telescopes
C2	UV Astronomy	Deep-sky survey and XUV telescopes
C3	Solar Observations	Solar variation photometer and instrument package
C4	Space Sciences 1	Communication laboratory plus plasma physics
C5	Space Sciences 2	Terrestrial noise and interference plus AMPS*
C6	AMPS/Earth Science	AMPS plus multispectral scanner
C7	Space Technology	Wall-less chemistry, superfluids, and space processing
C8	Cloud Physics/Technology	Zero-g cloud physics investigations plus material science
C9	Earth Science 1	Multifrequency radar plus laser
C10	Earth Science 2	Microwave radiometry plus scatterometry
C11	High-Energy Astronomy/Technology	Cosmic-ray physics and x-ray/gamma-ray astronomy
C12	Life Science/Technology 1	Life science and biology laboratory
C13	Life Science/Technology 2	Life science and materials laboratory
C14	IR/UV Astronomy	Combined 1.5-m IR and deep-sky UV telescopes
C15	UV Astronomy, Advanced	1-m diffraction-limited UV telescope plus survey
C16	Cosmic Ray Laboratory	Dedicated cosmic ray physics/superconducting magnet spectrometry
C17	Long-Duration Life Science Laboratory	720-day life science investigations
C18	Advanced Technology	Combination of advanced development investigations
C19	Space Manufacturing	Production of high-value materials

*Atmospheric, magnetospheric, and plasma physics in space

	MOSC PAYLOAD	1985	1986	1987	1988	1989	1990	1991	1992	1993	
28° ORBITS	C1	Δ	Δ								
	C7		Δ								
	C2		Δ Δ								
	C12			Δ	Δ	Δ	Δ				
	C13			Δ			Δ				
	C11				Δ Δ						
	C8					Δ					
	C3					Δ Δ			Δ Δ		
	C16							Δ			
	C17									Δ	
POLAR ORBITS	C4			Δ	Δ						
	C5			Δ		Δ					
	C6			Δ Δ							
	C9				Δ Δ						
	C10				Δ Δ						
	C18					Δ					
	C14					Δ	Δ				
	C15						Δ Δ				
	C19							Δ	Δ	Δ	
	TOTAL	1	4	6	8	7	5	2	3	2	38

CALENDAR YEAR — FLIGHTS

CONTINUING RESEARCH AND DEVELOPMENT PROGRAMS

- SOLAR POWER
- LIFE SCIENCES/HUMAN PERFORMANCE
- COMMERCIAL PROCESSING
- ADVANCED MATERIAL SCIENCE
- BASIC AND APPLIED PHYSICAL SCIENCE

Figure 5-1. MOF-SSPDA Payload Flight Schedule

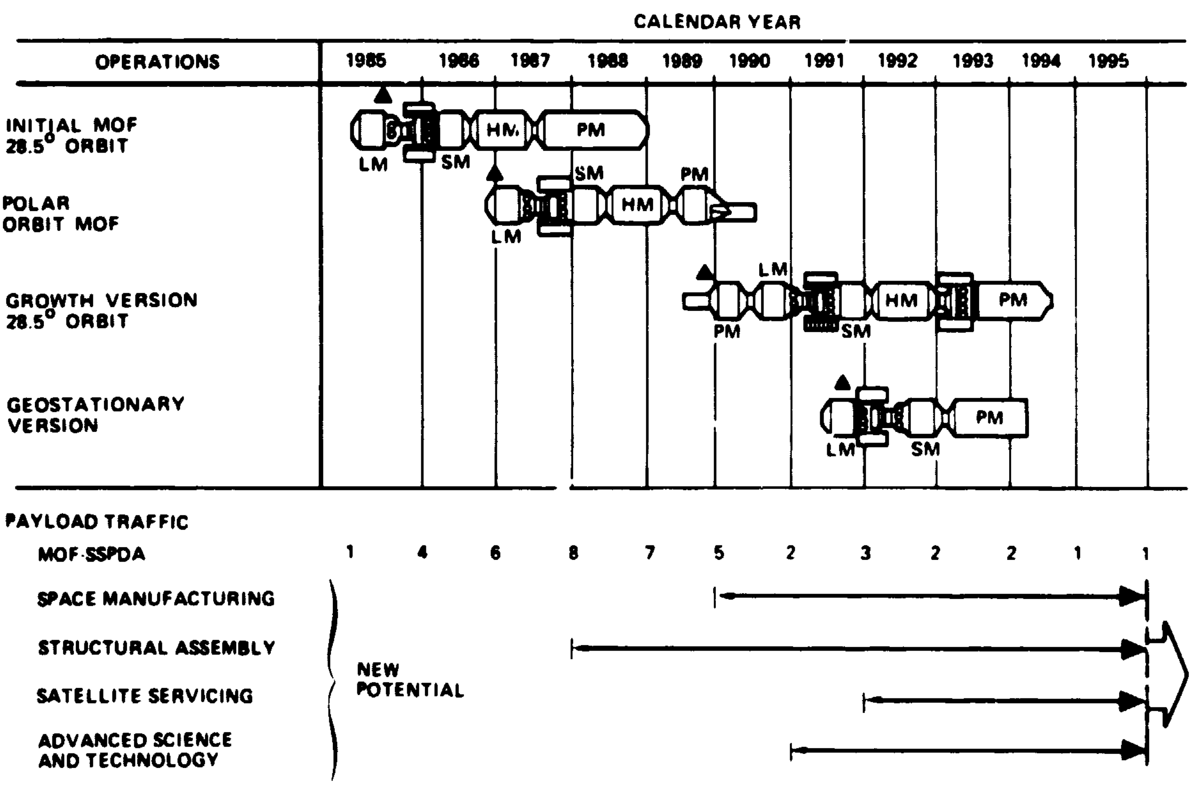


Figure 5-2. Representative MOF Program Evolution

The following examples are intended to illustrate the broad range of MOF payload accommodations. These examples typify some of the payload operations already proposed. It is hoped that potential MOF users will be stimulated by these descriptions to suggest additional payloads and activities.

PAYLOAD HANDLING

The versatility and availability of onboard maintenance, repair, and modification could be of substantial value to MOF users. Not only can individual payloads be serviced and maintained, but payloads can also be reconfigured in space (Figure 5-3). Logistic flights can provide necessary parts, as well as new equipment and supplies, for an essentially continuous operation. This continuity would be especially useful in pilot-plant and large-volume space-manufacturing operations.

If required observational programs are intermittent, there are distinct advantages to leaving payloads in orbit between their activity periods. For example, many instruments are sensitive to contamination. One such is the infrared astronomy telescope, which is adversely affected by effluents impinging upon the optical surfaces and thereby altering the spectral characteristics of the instrument. Since the MOF, including the PM's, can remain in orbit, the needed freedom from contamination can be preserved.

SATELLITE SERVICING OPERATIONS

Satellite servicing in orbit (Figure 5-4) is an additional option offered by MOF. Manual operations, as compared to an automated approach, have the potential to simplify servicing, fault isolation, repair, refurbishment, and checkout.

A payload module that is outfitted with a pressurized volume connected by an airlock to an unpressurized volume is particularly attractive for satellite servicing and repair. The pressurized compartment serves as a workshop where individual spacecraft elements can be serviced and repaired through use of conventional tools, test equipment, and alignment fixtures. A small equipment airlock situated in the aft hatch facilitates moving equipment between the two work areas. The unpressurized area serves as a hangar where the satellite to be serviced can be secured while the repair operations are undertaken. In both the pressurized and unpressurized areas, electrical power and other utilities are available, and other services such as CCTV, data recording, and computer-aided checkout can be provided. In this mode of operation, the MOF serves as a living area for the space workers and can form the fundamental building block for large factory complexes for manufacturing, assembly, maintenance, and repair of space facilities.

STRUCTURAL ASSEMBLY IN SPACE

Large space structures (Figures 5-5 and 5-6) offer the opportunity to develop scientific and observational capabilities that are not obtainable on earth. In addition to large-aperture radio telescopes, large devices have applications in the fields of communication, media broadcasting, surveillance, and advanced power-transmission concepts.

The assembly of large space telescopes, as an example, would be greatly simplified by the availability of man to rig and deploy the structure. Structural members could even be formed in space -- truss elements could be extruded, thereby requiring only the raw materials to be transported as cargo to the facility. The structure could be assembled with simple, sequential manual operations instead

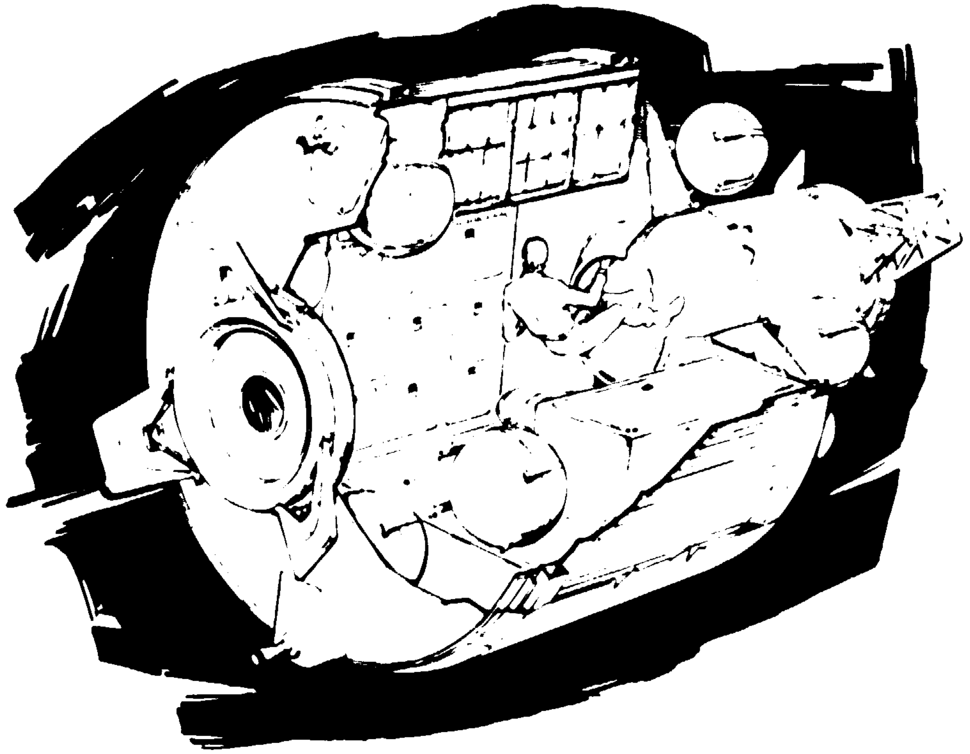


Figure 5-3. Payload Handling

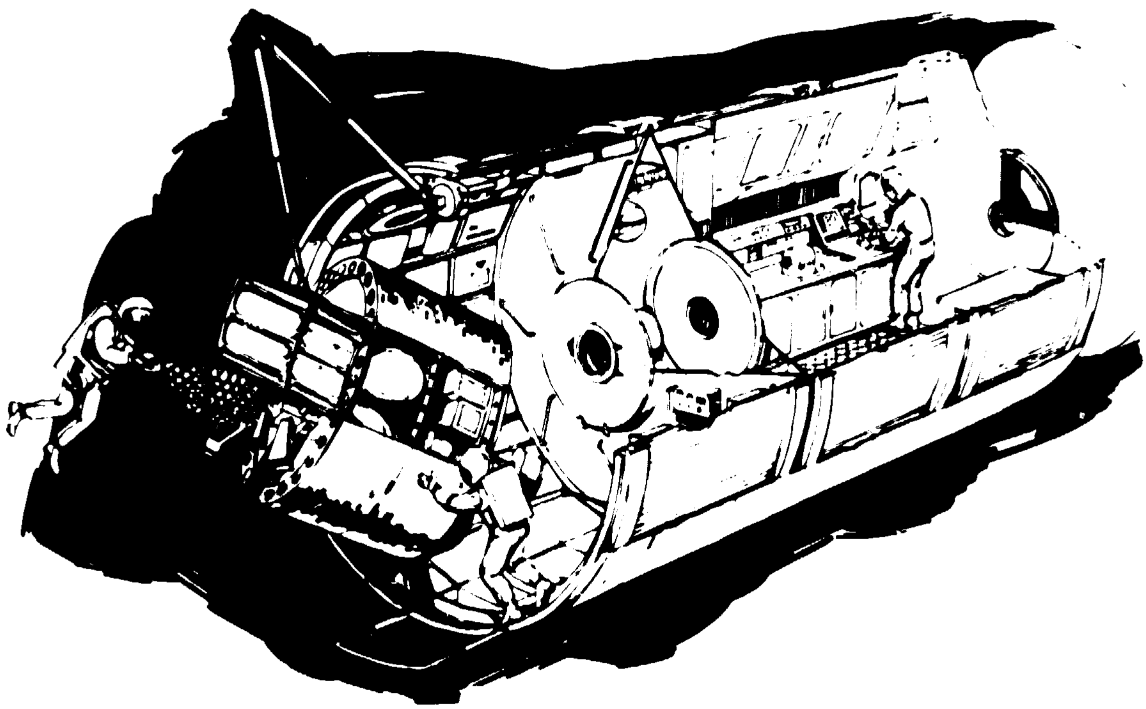


Figure 5-4. Satellite Servicing Operations

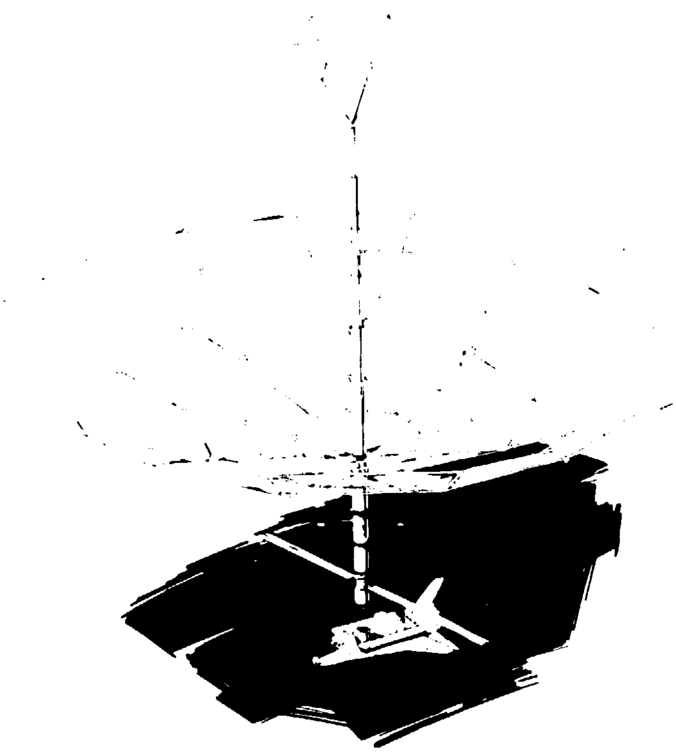


Figure 5-5. Deployment of Large Radio Telescope

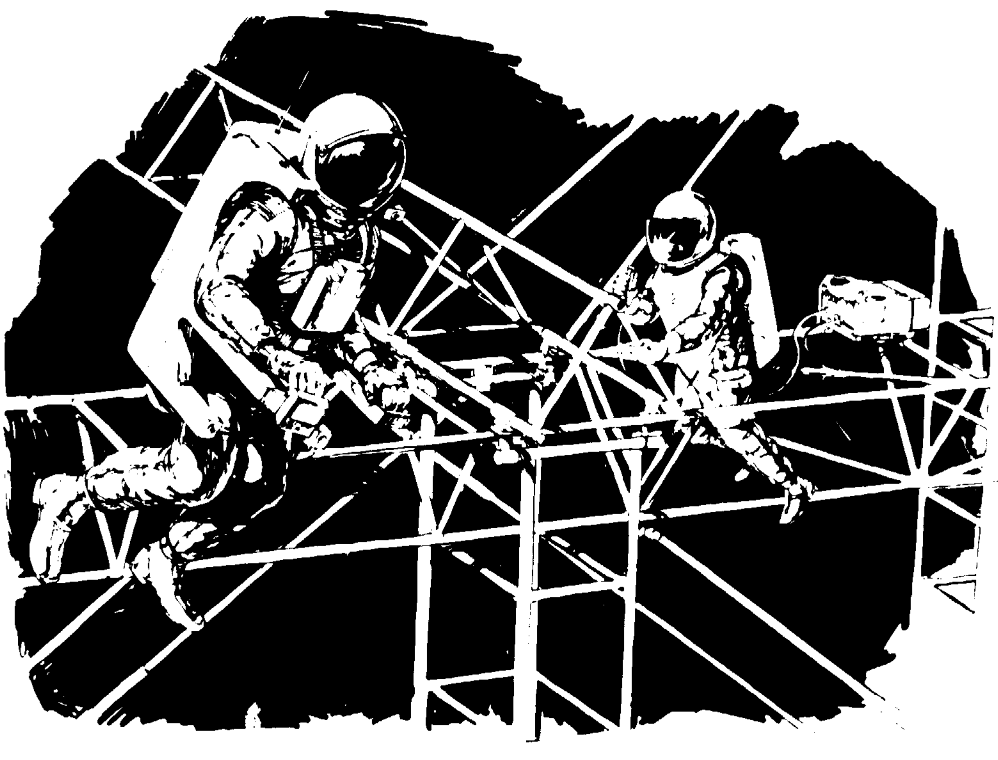


Figure 5-6. Structure Fabrication and Assembly in Space

of complex automated or remotely controlled procedures. The MOF offers the orbital platform on which to base these operations as well as to support the needs of the crew.

MANUFACTURING IN SPACE

The microgravity environment, in addition to its scientific interest, offers potential economic and industrial rewards (Figure 5-7). Materials could be produced in space that would possess unique and highly desirable features which would be prohibitively expensive or impossible to produce on earth. For example, space processing techniques that are currently being studied involve production of eutectic materials. Potentially valuable commercial eutectics include certain binary mixtures. When these mixtures solidify, one of the two phases can form fibers, filaments, or platelets in a matrix of the second phase. These materials when produced on earth are limited in perfection owing to discontinuities, faults, and surface irregularities caused by mechanical vibrations or gravity-induced thermal convection in the melt during solidification. If the solidification process is performed in microgravity, where vibration and mechanical disturbances are minimized, continuous fiberlike eutectics can be produced with special electrical, thermomagnetic, optical, and superconducting properties of immediate commercial value.

Production in microgravity would also be advantageous for many other promising processes and materials. Typical are growing of perfect, large-size crystals from a liquid or vapor phase; large-scale electrophoretic separation of biologicals; contamination-free, containerless melting and solidification; production of ultrapure substances; manufacture of microscale surface acoustic-wave components; and production of semiconductor-grade silicon in ribbon form as a substitute for conventional sliced-silicon slabs.

GENERAL-PURPOSE LABORATORY

A payload module will be outfitted as a general-purpose life-science laboratory (Figure 5-8). The facility will be provided with the standard instruments and analytical services necessary to pursue a broad range of reasearch in the life-science and health fields. These disciplines, perhaps uniquely more than others, can benefit from the MOF environment, where long-duration research is possible and continuous exposure to microgravity can be maintained for periods up to 720 days. Since many different investigations would use common equipment, the general-purpose laboratory would include basic capabilities such as microscopy, blood chemistry, metabolic analysis, fluid analysis, specimen preservation, and animal holding.

Other general-purpose laboratory configurations could be created to support investigations in physics, chemistry, material processing, space and plasma physics, cosmic-ray research, and earth observations.

PAYLOAD MONITORING AND CONTROL

The habitability module provides the control center and operational focus for payloads that are most conveniently monitored remotely (Figure 5-9). Communications and data-management services are available to assess payload performance, conduct real-time conferences with principal investigators on the ground, and coordinate operations with other facilities and locations. Mission plans can be discussed, and future flight activities can be adjusted as the needs of the users evolve.

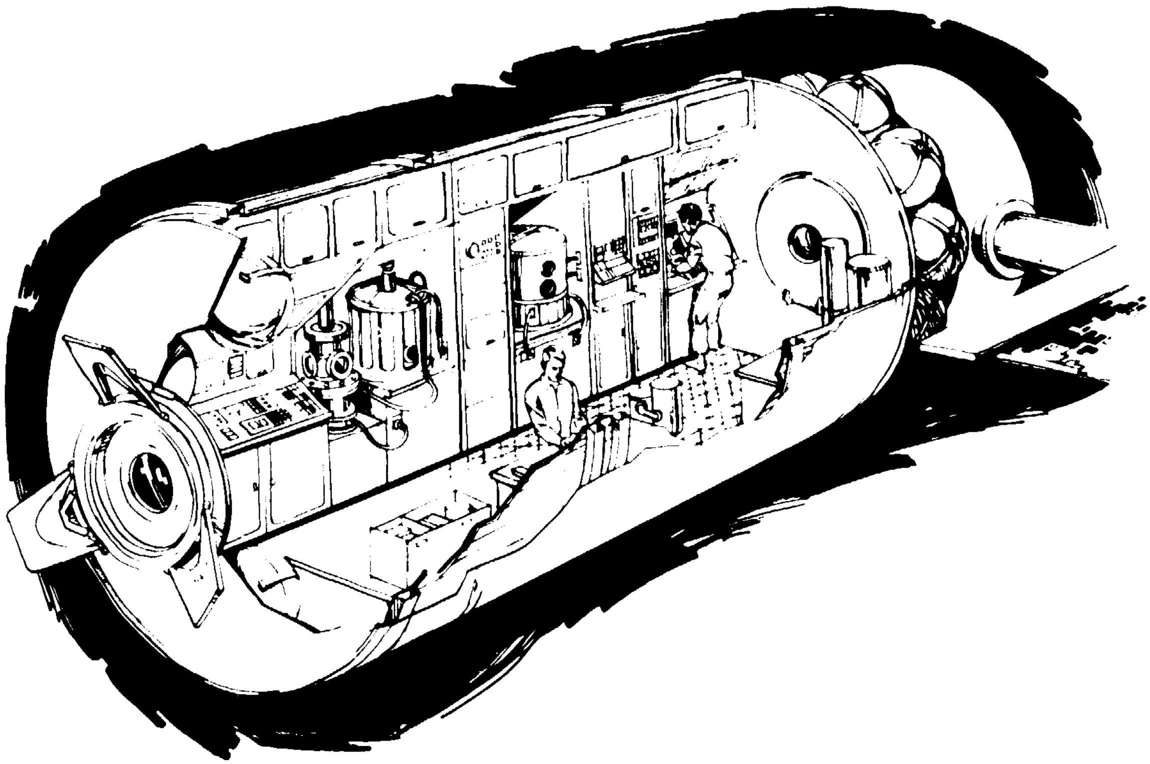


Figure 5-7. Manufacturing in Space

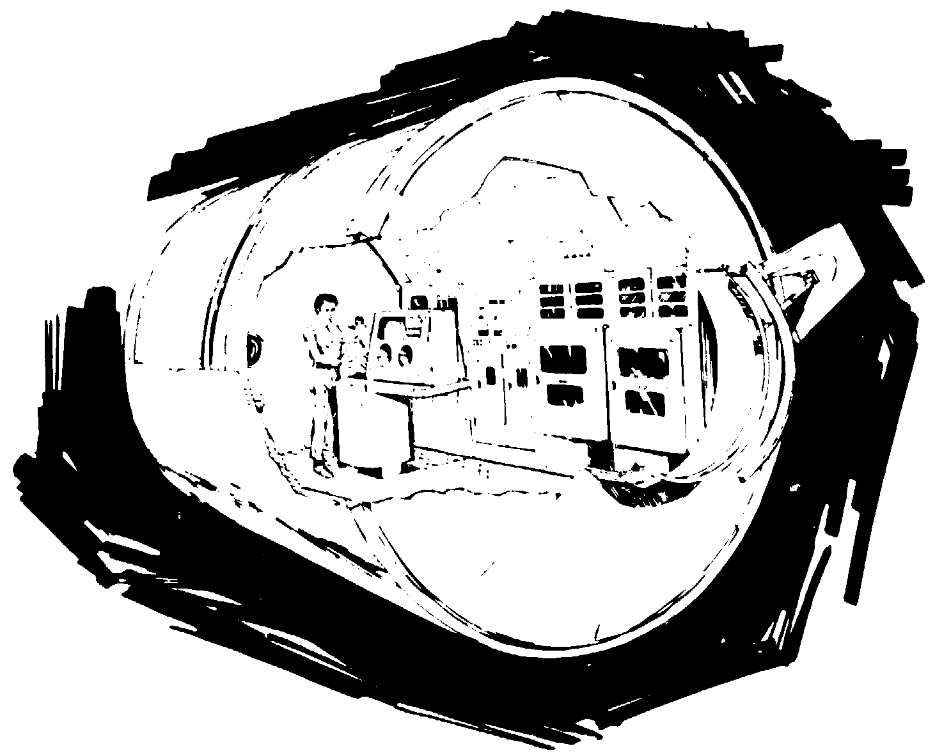


Figure 5-8. General-Purpose Laboratory

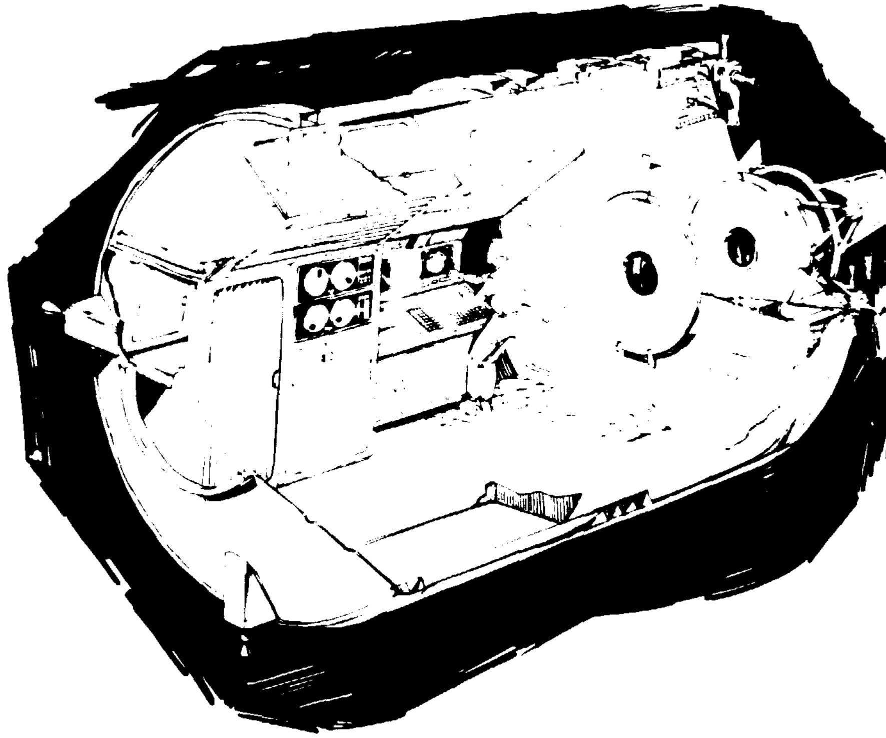


Figure 5-9. Payload Monitoring and Control

CRITICAL PAYLOAD OPERATIONS

Certain classes of payloads, such as the remote sensing instruments required in the astronomy and earth observations disciplines, require precision pointing and periods of time when activities onboard the MOF must be carefully controlled. When the onboard distrubances need to be minimized, the crew moves as close as possible to the center of gravity of the facility. By restricting crew motion during the critical periods, extremely low-vibration operation of the facility is achieved.

PAYLOAD SERVICING, OVERHAUL, AND REPAIR

The MOF is equipped with a full complement of standard tools such as wrenches, drivers, drills, bits, and cutters. Holding fixtures and restraints are provided to enable an equipment item to be repaired. Standard electronic voltmeters, test oscillators, and oscilloscopes are provided for troubleshooting, fault isolation, and determination of corrective action. Spare parts kits and accessories are available, including supplies such as adhesives, fasteners, lubricants, electrical wire, solder, insulating tape, and cleaning materials. Storage space is also provided for payload-unique spare parts and for equipment items that might be required during flight.

6 PAYLOAD DESCRIPTIONS, GENERAL USER NEEDS, AND QUESTIONNAIRE

A standardized format has been devised for description of MOF payloads and payload-accommodation requirements. Three samples covering representative MOF payloads are included as illustrations of the type of payload-accommodation data that would be useful in future MOF definition studies. If such definitive information is readily available, the reader is encouraged to provide it to NASA-Marshall Space Flight Center to aid current MOF planning activities. Blank forms are available for this purpose.

Potential MOF users are encouraged to indicate their general interests or projected payload requirements and desires to NASA by submitting the questionnaire at the end of this publication. The questionnaire may be supplemented as desired by additional data. Comments and recommendations relative to the basic MOF design approach or to suggested improvements or changes are encouraged, and requests for further information are welcome.

MOF PAYLOAD DATA SHEET
LEVEL A

PAYLOAD NO. ____________

PAYLOAD NAME Large Radio Telescope Erection

USER/AGENCY ____________

PREPARATION DATE 4-17-75 **REVISION DATE** ________ **LTR** ____

PURPOSE Investigating RF Sources in Space in the 5 MHz to 10 MHz Band

APPLICATION

- ☐ SCIENTIFIC
- ☐ TECHNOLOGICAL/ENGINEERING
- ☐ MATERIAL PRODUCTION
- ☒ MANUFACTURING/ASSEMBLY
- ☐ SATELLITE RECOVERY
- ☐ SATELLITE REPAIR
- ☐ OBSERVATORY
- ☐ CONTROL CENTER
- ☐ EDUCATION
- ☐ MASS MEDIA
- ☐ OTHER (SPECIFY)

PAYLOAD TYPE/MODE

- ☐ PRESSURIZED MODULE
- ☐ PLATFORM/PALLET
- ☒ UNPRESSURIZED MODULE
- ☐ FREE-FLYER
- ☐ COMBINATION

DESIRED FLIGHT DURATION 90(1) DAYS

NUMBER OF FLIGHTS PER YEAR

1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
						1						

OPERATIONAL ORBIT CHARACTERISTICS

	DESIRED	MINIMUM	MAXIMUM
ALTITUDE, APOGEE (km)	400(2)	300	500
ALTITUDE, PERIGEE (km)	400	300	500
INCLINATION (DEG)	28.5	28.5	28.5

MAJOR PAYLOAD EQUIPMENT

NAME	DESCRIPTION	OPERATION/FUNCTION
Radio telescope	200 m dia reflector	The telescope is docked to the MOF for erection and checkout in low earth orbit. For operation, the telescope is boosted into high earth orbit utilizing a Tug.

SPECIAL REQUIREMENTS/REFERENCES

(1) Period required for erection and space assembly. Telescope operating period is 1,000 days minimum.

(2) Altitude of erection only. Operating altitude is 4,000-8,000 km.

MOF PAYLOAD DATA SHEET
LEVEL A

PAYLOAD NO. ________

PAYLOAD NAME Large Radio Telescope Erection PAYLOAD MODEL CODE NO. ________

PHYSICAL CHARACTERISTICS

WEIGHT AT LAUNCH	
PRESSURIZED (kg)	
UNPRESSURIZED (kg)	25,000 lb
CONSUMABLES (kg)	
FLIGHT EXPENDABLES (kg)	
VOLUME – PRESSURIZED (m^3)	
VOLUME – UNPRESSURIZED (m^3)	

ENVIRONMENTAL REQUIREMENTS IN FLIGHT	MODE / LOCATION	OPERATING PRESS	OPERATING UNPRESS	NONOPERATING PRESS	NONOPERATING UNPRESS
TEMPERATURE (°K)	MAX				
	MIN				
HUMIDITY (%)	MAX				
CLEANLINESS CLASS					
ACOUSTIC LIMIT (dB)					
ACCELERATION LIMIT (g)					
RADIATION LIMITS					

OPERATIONAL REQUIREMENTS

PAYLOAD PERSONNEL/SKILLS
- NUMBER OF PERSONNEL 3
- TOTAL MAN-HOURS PER DAY 20.0 avg
- TOTAL MAN-HOURS PER FLIGHT 1800
- PAYLOAD OPERATION 1 SHIFT ☒ 2 SHIFTS ☐
- EVA'S PER FLIGHT 80 NO. PERSONNEL 2
- AVERAGE DURATION OF EVA (HR) ________

PAYLOAD POWER

	DC (W)	AC (W)
AVERAGE		
PEAK		
ASCENT/DESCENT		

PEAK POWER DURATION (HR) ________
TOTAL ENERGY (kWH) ________

POINTING REQUIREMENTS (IF APPLICABLE
- ACCURACY (ARC SEC) 10
- DURATION (HR/OPN) 2 hr
- REPETITION RATE (OPN/DAY) 1
- TOTAL POINTING TIME (HR/FLIGHT) ________
- STABILITY (ARC SEC) ________
- DURATION (HR/OPN) ________
- STABILITY RATE (ARC SEC/SEC) ________
- VIEWING REQUIREMENTS ________
- VEHICLE ORIENTATION

SKETCH OR BLOCK DIAGRAM BRIEFLY DESCRIBING PAYLOAD

DATA AND COMMUNICATIONS

IS USE OF TDRS/STDN REQUIRED? YES ☐ NO ☐

VOICE UP? YES ☐ NO ☐ VOICE DOWN? YES ☐ NO ☐

FILM/TAPE STORAGE WEIGHT (kg) VOLUME (m^3)

DESCRIBE REQUIREMENTS FOR ONBOARD DATA RECORDING AND CCTV:

DESCRIBE REQUIREMENTS FOR REAL-TIME DATA TRANSFER:

DESCRIBE REQUIREMENTS FOR GROUND MONITORING AND CONTROL:

COMPUTER SUPPORT REQUIRED? YES ☐ NO ☐ COMPUTATIONAL LOAD (CPU MIN/DAY) ________

BULK MEMORY ________ REPROGRAMMING YES ☐ NO ☐

REMARKS:

MOF PAYLOAD DATA SHEET
LEVEL A

PAYLOAD NO. ____________

PAYLOAD NAME Space Manufacturing Facility

USER/AGENCY NASA

PREPARATION DATE 4-18-75 **REVISION DATE** ____________ **LTR** New

PURPOSE Production of Isoenzymes and Metals in Space

APPLICATION

- ☐ SCIENTIFIC
- ☐ TECHNOLOGICAL/ ENGINEERING
- ☐ MATERIAL PRODUCTION
- ☒ MANUFACTURING/ ASSEMBLY
- ☐ SATELLITE RECOVERY
- ☐ SATELLITE REPAIR
- ☐ OBSERVATORY
- ☐ CONTROL CENTER
- ☐ EDUCATION
- ☐ MASS MEDIA
- ☐ OTHER (SPECIFY)

PAYLOAD TYPE/MODE

- ☒ PRESSURIZED MODULE
- ☐ PLATFORM/PALLET
- ☐ UNPRESSURIZED MODULE
- ☐ FREE-FLYER
- ☐ COMBINATION

DESIRED FLIGHT DURATION: 60(1) DAYS

NUMBER OF FLIGHTS PER YEAR

1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
						1	1	1	1	1	1	1

OPERATIONAL ORBIT CHARACTERISTICS

	DESIRED	MINIMUM	MAXIMUM
ALTITUDE, APOGEE (km)	Any	Any	Any
ALTITUDE, PERIGEE (km)	Any	Any	Any
INCLINATION (DEG)	90(2)	Any	Any

MAJOR PAYLOAD EQUIPMENT

NAME	DESCRIPTION	OPERATION/FUNCTION
Furnace 1	Levitated-melt electron-beam furnace	Melts metal in levitated state
Furnace 2	Heat-treat furnace	Heat treatment of metallic materials
Separation cover	Electrophoresis separation apparatus	Segregates 150 enzymes according to electrical surface charge properties
Control console	Contains controls, monitors, displays	Controls furnaces and electrophoesis separation column
TV system	Cameras, monitors	Monitors operations in furnaces, transmits findings to earth

SPECIAL REQUIREMENTS/REFERENCES

(1) Operational period per year to produce materials for return to earth; payload equipment may be returned or stored in orbit.

(2) This inclination will take advantage of high beta angles with solar arrays in extended periods of sunlight, thereby increasing the available payload power substantially.

MOF PAYLOAD DATA SHEET
LEVEL A

PAYLOAD NO. ________

PAYLOAD NAME Space Manufacturing Facility   PAYLOAD MODEL CODE NO. ________

PHYSICAL CHARACTERISTICS	
WEIGHT AT LAUNCH	
PRESSURIZED (kg)	2,400
UNPRESSURIZED (kg)	---
CONSUMABLES (kg)	800
FLIGHT EXPENDABLES (kg)	--
VOLUME – PRESSURIZED (m^3)	10
VOLUME – UNPRESSURIZED (m^3)	--

ENVIRONMENTAL REQUIREMENTS IN FLIGHT	MODE	OPERATING		NONOPERATING	
	LOCATION	PRESS	UNPRESS	PRESS	UNPRESS
TEMPERATURE (°K)	MAX	298		298	
	MIN	292		292	
HUMIDITY (%)	MAX	70		70	
CLEANLINESS CLASS		100K		100K	
ACOUSTIC LIMIT (dB)		80			
ACCELERATION LIMIT (g)		1E-04		4	
RADIATION LIMITS		N/A			

OPERATIONAL REQUIREMENTS

PAYLOAD PERSONNEL/SKILLS
- NUMBER OF PERSONNEL 4
- TOTAL MAN-HOURS PER DAY 16
- TOTAL MAN-HOURS PER FLIGHT 1,440
- PAYLOAD OPERATION 1 SHIFT ☐ 2 SHIFTS ☒
- EVA'S PER FLIGHT ____ NO. PERSONNEL ____
- AVERAGE DURATION OF EVA (HR) ____

PAYLOAD POWER

	DC (W)	AC (W)
AVERAGE	9,200	--
PEAK	20,000	--
ASCENT/DESCENT	--	--

PEAK POWER DURATION (HR) TBD (1)
TOTAL ENERGY (kWH) 1,400

POINTING REQUIREMENTS (IF APPLICABLE
- ACCURACY (ARC SEC) --
- DURATION (HR/OPN) --
- REPETITION RATE (OPN/DAY) --
- TOTAL POINTING TIME (HR/FLIGHT) --
- STABILITY (ARC SEC) --
- DURATION (HR/OPN) --
- STABILITY RATE (ARC SEC/SEC) --
- VIEWING REQUIREMENTS --
- VEHICLE ORIENTATION --

SKETCH OR BLOCK DIAGRAM BRIEFLY DESCRIBING PAYLOAD

DATA AND COMMUNICATIONS

IS USE OF TDRS/STDN REQUIRED? YES ☒ NO ☐

VOICE UP? YES ☒ NO ☐ VOICE DOWN? YES ☒ NO ☐

FILM/TAPE STORAGE WEIGHT (kg) VOLUME (m^3)

DESCRIBE REQUIREMENTS FOR ONBOARD DATA RECORDING AND CCTV:
TV to ground of selected operations and resulting materials

DESCRIBE REQUIREMENTS FOR REAL-TIME DATA TRANSFER: None

DESCRIBE REQUIREMENTS FOR GROUND MONITORING AND CONTROL: None

COMPUTER SUPPORT REQUIRED? YES ☐ NO ☒   COMPUTATIONAL LOAD (CPU MIN/DAY) ________

BULK MEMORY ________   REPROGRAMMING YES ☐ NO ☐

REMARKS: (1) Peak energy duration is dependent on operational timelines. These must be developed to reduce amount of concurrent operations.

MOF PAYLOAD DATA SHEET
LEVEL A

PAYLOAD NO. ____________

PAYLOAD NAME Long-Duration Life Sciences Laboratory

USER/AGENCY NASA

PREPARATION DATE 5-1-75 **REVISION DATE** ________ **LTR** New

PURPOSE Provide Capability to Accomplish Life Sciences Research and Development Requiring Long On-Orbit Stay Time (30 Days to 1 Year)

APPLICATION
☒ SCIENTIFIC
☐ TECHNOLOGICAL/ ENGINEERING
☐ MATERIAL PRODUCTION
☐ MANUFACTURING/ ASSEMBLY
☐ SATELLITE RECOVERY
☐ SATELLITE REPAIR
☐ OBSERVATORY
☐ CONTROL CENTER
☐ EDUCATION
☐ MASS MEDIA
☐ OTHER (SPECIFY)

PAYLOAD TYPE/MODE

☒ PRESSURIZED MODULE	☐ PLATFORM/PALLET	DESIRED FLIGHT DURATION
☐ UNPRESSURIZED MODULE	☐ FREE-FLYER	
☐ COMBINATION		720 DAYS

NUMBER OF FLIGHTS PER YEAR

1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
								1				

OPERATIONAL ORBIT CHARACTERISTICS

	DESIRED	MINIMUM	MAXIMUM
ALTITUDE, APOGEE (km)	370	Any	Any
ALTITUDE, PERIGEE (km)	370	Any	Any
INCLINATION (DEG)	28.5	Any	Any

MAJOR PAYLOAD EQUIPMENT

NAME	DESCRIPTION	OPERATION/FUNCTION
Blood & urine sampling eq	Blood & urine acq kits & freezers	Collect, prepare, & preserve blood & urine samples
Electrophysiological meas eq	Sensors, sig cond, displ units, & recorders	Measure ECG, VCG, heart rate, EEG, EMG, & other bioelectric potentials
Vestibular functional test eq	Rotating litter chair & test eq	Nausea susceptibility, acceleration thresholds, orientation tests
Metabolic test & measurement eq	Ergometer, gas anal, pulmon funct units	Metabolic cost of exercise, physical conditioning, and pulmonary function
Blood & urine analysis eq	Sample prep, microscopes, cameras, fluid anal	Metabolic & electrolyte balances, musculoskeletal integrity
Cardiovascular function test eq	LBNP, blood press, plethysmograph, pulse wave, sonocardiograph	Vascular pressures & reactivities, heart functions other than electrical
Specimen holding facility	Hold units for primates, sm verts, inverts, plants	Cont & maint specimens (food, water, waste mgt, envir cont)
Specimen examination eq	Biomedical diagnostic kit and bay	Gross & microscopic examination, specimen stimulation & recording
Man-systems integ and suppt eq	Dimens meas dev & test	Dimens & postural changes, & opnl & sim task measures
Life & protective syst eq	LSS test console & pres suit eq	Funct tests of LSS envir units, EVA tests

SPECIAL REQUIREMENTS/REFERENCES

MOF PAYLOAD DATA SHEET
LEVEL A

PAYLOAD NO. ________

PAYLOAD NAME Long-Duration Life Sciences Laboratory PAYLOAD MODEL CODE NO. LS

PHYSICAL CHARACTERISTICS

WEIGHT AT LAUNCH
- PRESSURIZED (kg) 18,000
- UNPRESSURIZED (kg) 0
- CONSUMABLES (kg) 2250
- FLIGHT EXPENDABLES (kg) 2250

VOLUME PRESSURIZED (m^3) 100

VOLUME - UNPRESSURIZED (m^3)

ENVIRONMENTAL REQUIREMENTS IN FLIGHT	OPERATING PRESS	OPERATING UNPRESS	NONOPERATING PRESS	NONOPERATING UNPRESS
MODE / LOCATION	PRESS	UNPRESS	PRESS	UNPRESS
TEMPERATURE (°K) MAX				
TEMPERATURE (°K) MIN				
HUMIDITY (%) MAX		X		
CLEANLINESS CLASS				
ACOUSTIC LIMIT (dB)		X	X	
ACCELERATION LIMIT (g)				
RADIATION LIMITS			X	X

OPERATIONAL REQUIREMENTS

PAYLOAD PERSONNEL/SKILLS
- NUMBER OF PERSONNEL 4
- TOTAL MAN-HOURS PER DAY 32
- TOTAL MAN-HOURS PER FLIGHT 23,200
- PAYLOAD OPERATION 1 SHIFT ☒ 2 SHIFTS ☐
- EVA'S PER FLIGHT 0 NO PERSONNEL 0
- AVERAGE DURATION OF EVA (HR) 0

PAYLOAD POWER

	DC (W)	AC (W)
AVERAGE	8000	
PEAK	8000	
ASCENT/DESCENT	1000	

PEAK POWER DURATION (HR) --

TOTAL ENERGY (kWH) 94,800

POINTING REQUIREMENTS (IF APPLICABLE
- ACCURACY (ARC SEC) ________
- DURATION (HR/OPN) ________
- REPETITION RATE (OPN/DAY) ________
- TOTAL POINTING TIME (HR/FLIGHT) ________
- STABILITY (ARC SEC) ________
- DURATION (HR/OPN) ________
- STABILITY RATE (ARC SEC/SEC) ________
- VIEWING REQUIREMENTS ________
- VEHICLE ORIENTATION

SKETCH OR BLOCK DIAGRAM BRIEFLY DESCRIBING PAYLOAD

DATA AND COMMUNICATIONS

IS USE OF TDRS/STDN REQUIRED? YES ☒ NO ☐

VOICE UP? YES ☒ NO ☐ VOICE DOWN? YES ☒ NO ☐

FILM/TAPE STORAGE WEIGHT (kg) VOLUME (m^3)

TBD

DESCRIBE REQUIREMENTS FOR ONBOARD DATA RECORDING AND CCTV

TBD

DESCRIBE REQUIREMENTS FOR REAL TIME DATA TRANSFER:

TBD

DESCRIBE REQUIREMENTS FOR GROUND MONITORING AND CONTROL

TBD

COMPUTER SUPPORT REQUIRED? YES ☐ NO ☐ COMPUTATIONAL LOAD (CPU MIN/DAY) ________

BULK MEMORY ________ REPROGRAMMING YES ☐ NO ☐

REMARKS:

National Aeronautics and Space Administration
Marshall Space Flight Center
Alabama 35812

Attention: Mr. C.C. Priest, PS04
Telephone: (205) 453-2769

MANNED ORBITAL FACILITY USER'S QUESTIONNAIRE

NAME____ TELEPHONE______________

ADDRESS____

ORGANIZATION YOU REPRESENT_______________________________________

____

DESCRIBE YOUR SPECIALTY AS IT RELATES TO MOF_____________________

____

____

YOUR INTEREST AS A POTENTIAL MOF USER IS PRIMARILY IN

_______ BASIC RESEARCH (E.G., ASTRONOMY)

_______ APPLICATIONS (E.G., EARTH OBSERVATIONS)

_______ ORBITAL OPERATIONS (E.G., MANUFACTURING IN SPACE)

_______ SERVICING (E.G., SATELLITE REFURBISHMENT)

_______ OTHER (SPECIFY)

BRIEFLY DESCRIBE YOUR REQUIREMENTS AND PAYLOAD CHARACTERISTICS

____

____

____

____

WHAT ARE YOUR PROGRAM REQUIREMENTS (SCHEDULE, NUMBER OF FLIGHTS, TOTAL DURATION)?____

____

____

COMMENTS ON MOF FEATURES AND DESIRED CHANGES_____________________

____

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